A RAND NOTE

Apogee, Perigee, and Recovery: Chronology of Army Exploitation of Space

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Prepared for the
United States Army

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PREFACE

This study was conducted in RAND's Arroyo Center by an Army Fellow working within the Applied Technology program. The research is associated with and contributes to a continuing series of products of the "Army Exploitation of Space" project sponsored by the Director, Space and Special Weapons within the Office of the Deputy Chief of Staff for Operations and Plans.

The Note should be of interest to military or civilian personnel seeking a systemic understanding of the ground service's development and application of space in the technology areas of long-range missiles, satellites, ground stations, and ballistic missile defense.

The cutoff date for this study, March 31, 1989, corresponded with the completion of the author's tour as an Army Fellow at RAND. Since then a number of significant events have occurred that affect the Army's role in space. For instance, major changes in the Soviet Union and the Warsaw Pact during 1989–1990 have reshaped the geostrategic relationships for the United States. The effects of these changes on the Army are not yet fully understood. However, it is expected that the military budgets will be reduced substantially; there will be a major reduction in overseas basing of forces; and future CONUS-based forces will need to be prepared to deploy globally. Other significant space-related events include:

- July 26, 1990: The Army Space Council approved further exploration of the technology for the development of tactical surveillance/target acquisition and communications satellites.
- August 1990–February 1991: Operation Desert Shield/Storm was successfully conducted against Iraq's invasion of Kuwait. Space systems played a significant role in supporting the Army in Joint Operations along with forces from the coalition of other nations. For example, the Satellite Lightweight GPS Receiver (SLGR) was used extensively in support of artillery, air defense, and combat engineer activities. Also, space tip-off of the SCUD theater missile launches provided warning to the Patriot's batteries. Communications support provided by MILSATCOM and commercial communications satellites, for both in-theater and global operations, was important for the Army. In addition, imagery support from

TENCAP as well as from commercial satellite systems such as SPOT and LANDSAT proved to be extremely useful to the Army.

- December 1990–January 1991: The Army, as executive service/manager of the joint service ASAT program, decided to substantially scale back the ASAT program.
- October 1990: USARSPACE assumed command of the Defense Satellite Communications System (DSCS) including the operation centers from USAISC.
- January 21, 1991: The President directed that the Strategic Defense Initiative (SDI) program be "refocused on providing protection from limited ballistic missile strikes, whatever their source." This redirection also called for "an SDI program that can deal with any future threat to the United States, to our forces overseas and to our friends and allies."

THE ARMY FELLOWS PROGRAM

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Committee, which is co-chaired by the Army Vice Chief of Staff and by the Assistant Secretary for Research, Development, and Acquisition. Arroyo Center work is performed under contract MDA903-91-C-0006.

The Arroyo Center is housed in RAND's Army Research Division. The RAND Corporation is a private, nonprofit institution that conducts analytic research on a wide range of public policy matters affecting the nation's security and welfare.

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SUMMARY

BACKGROUND

During the past six or seven years, a debate has gone on within the Department of Defense (DoD) on whether it is appropriate for the Army to be increasingly involved in space and, if so, how should the Army exploit space. Although policy decisionmakers and senior operational commanders, who will influence the outcome of this debate, should be knowledgeable of the Army's historical role and utilization of space, few DoD personnel, classified documents, or open literature sources can explain the chronology of the U.S. Army in space, especially beyond 1961.

PURPOSE

The purpose of this Note is threefold. First, it is intended to describe the evolution of the Army's exploitation of space in response to an emerging post-World War II Soviet threat while complying with national policy and organizational directives. This first purpose is accomplished by providing a systems analysis/organizational explanation of:

- How the Army became America's preeminent pioneer in reliable booster development, launch, and space operations by 1960.
- How the Army's space exploitation efforts were constrained between 1961 and 1976.
- The recovery actions the Army has implemented since 1976 to exploit space.
- Four problems impeding future progress.

The second purpose is to inform the Army, military service school students, that part of the DoD that works daily on space matters, and the space research community of the full spectrum of the Army's past and current exploitation of space. This purpose is accomplished by providing a chronology of policy decisions and events, from 1907 through mid-1989, which have shaped the Army's exploitation in the technological areas of ballistic missiles, satellites, early warning radars, ground stations, anti-satellite (ASAT) defenses, anti-ballistic missile (ABM) defenses, theater missile defenses (TMD), and tactical missiles.

The final purpose is to assist DoD and Army leaders in making better informed analysis and decisions about how the Army ought to exploit space in the future.

By studying the systems analysis and chronology, the reader will learn that the Army has a long history of:

- Responding to presidential, congressional, and DoD guidance.
- Conducting space exploitation research and development (R&D), applying the results, and directly improving national security and national warfighting capabilities.
- Conducting traditional ground-fighting functions and operations with increasing application of space orbiting and space transiting assets. These traditional functions and operations include:
  - — Providing command and control of ground forces within the theater and providing long-haul communication to the National Command Authority (NCA).
  - — Using weather, geodesy, and intelligence information to improve operations.
  - — Providing continental and theater ABM, ASAT, and tactical missile defense.
  - — Applying force on the enemy with long-range weapons.

The term "exploitation of space," as employed in this Note, means gaining deterrence, crisis management, or war fighting benefit for a ground force commander from signals, beams, or missiles, whether those benefits come from an asset orbiting the earth or from a signal, beam, or missile temporarily transiting space.

Under this definition, the spectrum of exploitation includes three capabilities:

1. Enhancing ground operations by observing the environment and the enemy, as well as by communicating critical time-sensitive information.
2. Controlling space by preventing the enemy from observing or communicating from space and/or by preventing enemy transit of space.
3. Applying force by delivering timely targeting information to friendly ground forces or by delivering force from space.

APOGEE SUMMARY

By the end of 1945, the Army had significant R&D and combat experience in the following areas:

- Aerial intelligence gathering, processing, and dissemination.
- Signals intelligence gathering, processing, and dissemination.
- Development and operation of global, long-haul communication ground stations, including encryption and synchronization.
- Anti-aircraft and anti-missile air defense early warning.
- Solid- and liquid-propellant rocket propulsion development.

During the period 1945 through 1961, the U.S. Army's solid- and liquid-propellant missile booster propulsion, guidance, warhead handling, nose cone survival, satellite, and air defense R&D "firsts" solved a majority of space technology problems. This R&D effort directly led to getting America into space and represented a major contribution to national security. The apogee of Army involvement in space was demonstrated by successful applications, such as the development of reliable boosters and orbiting the first U.S. satellite, along with national recognition and dedicated service interest in exploiting space technology during the years 1958 through 1961.

However, by the mid-1940s the Army began to face a utility and national security challenge whenever the ground service requested DoD approval and funds to conduct space exploitation or related research. The challenge had five parts:

1. Show how the new Army capability, during deployment and operation, will not destabilize U.S.-USSR relations.
2. Show how the new capability overcomes a new vulnerability or is beneficial to performing traditional or assigned Army missions.
3. Show why the Army should perform this research instead of another government agency or service.
4. Show that the new capability/asset/system is cost-effective compared with alternative ground-based systems.
5. Show there is sufficient technological maturity to actually perform as claimed.

PERIGEE SUMMARY

During the perigee years of 1961 through 1976, the Army did not "lose" its lead in space exploitation. Instead it steadily advanced its ballistic missile force application capability, supported theater commanders by extensively developing and using satellite/ground-station-delivered long-haul communications, and deployed advanced ABM and ground-launched ASAT space control capabilities. Furthermore, the Army's substantial

missile R&D effort of the 1950s provided the ground-service with the technological basis to rapidly field small, lethal tactical missiles in NATO and Vietnam during the 1970s.

However, the ground service was forced to respond to powerful constraining influences which caused it to abandon satellite launches, reconnaissance satellite R&D, and operations and also to deactivate its ASAT and ABM capabilities. Beginning in 1958 and ending in mid-1961, the Army transferred to the National Aeronautics and Space Administration (NASA) thousands of highly trained scientific and engineering personnel, significant missile R&D facilities, and major launch vehicle and satellite development programs. DoD's 1960 directive 5160.32 prevented the Army from performing reconnaissance satellite development, space launch, or space system operations. Furthermore, DoD centralization efforts also constrained independent Army space efforts. In Vietnam, the Army complied with its national role of conducting ground combat when called upon. There it spent over a decade fighting a theater ground war while paying little regard to space exploitation requirements. Instead it focused much of its high-technology efforts on developing less costly and more immediately helpful small battlefield missiles. During these years the Army did exploit long-haul satellite/ground station communication capabilities, but did so in a tri-service mode. The Army also pioneered ABM and ASAT technology advances, but by 1976 its ABM and ASAT operational units were dismantled. So by 1976, the Army had dropped to its lowest point, its perigee, in exploiting space.

RECOVERY SUMMARY

The Army's recovery was initially slow from 1977 through 1982. Its emergence was first demonstrated by employment of national as well as other services' post-Vietnam space assets within the Tactical Exploitation of National Capabilities (TENCAP) program. Development by 1982 of the concept-based requirements system (CBRS) acquisition process and the AirLand Battle (ALB) doctrine represented the next recovery actions. ALB war fighting requirements supported the need to exploit space.

President Reagan's Strategic Defense Initiative (SDI) effort greatly empowered and funded the Army in 1983 to unleash its expertise in pioneering ABM applications. U.S. Army Strategic Defense Command (USASDC) rapidly demonstrated its space skills through several successful sensor, missile, and battle management technology experiments. The 1983 through 1988 Homing Overlay Experiment (HOE), Surveillance Acquisition Track and Kill Assessment (SATKA) Integrated Experiments (SIE), Experimental Version 1988 (EV88), and Flexible Lightweight Agile Guided Experiment

(FLAGE) tests were technology firsts reminiscent of the pioneering advances the Army was noted for during the 1950s.

Clearly, 1984 through 1989 was a watershed recovery period for the Army. By 1985 the Army published an interim space operations concept and the Army Space Initiative Study (ASIS) report providing a vision of how to exploit space. During 1986 and 1987, the Army implemented the ASIS recommendations by developing a space concept, master plan, draft architecture, and acquisition strategy. It specified space exploitation missions and roles for the Army staff, for USARSPACE as user/operator, for Army Space Institute as combat developer, and for two materiel developer organizations—USASDC and Army Materiel Command (AMC). This reorganization established a proactive infrastructure that is currently performing the following space exploitation recovery tasks:

1. Debating and defining how the Army should exploit space during the 1980s, 1990s, and beyond.
2. Developing doctrinal and operational concepts.
3. Providing a space command headquarters to execute missions and control operational units as they are defined and assigned.
4. Providing a cadre of space-qualified soldiers.
5. Providing requirements for system acquisition.
6. Participating in fielding new asset capabilities, such as the Global Positioning System (GPS).
7. Conducting R&D of ballistic missiles, tri- and individual service satellite/ground station networks, ABM, ASAT, and TMD systems.
8. Promoting Army space exploitation.
9. Analyzing the utility of satellites and anti-satellites for ground combat operations.

Even though the Army has not yet clearly defined the requirements for future Army-tailored space systems, its overall recovery actions reveal its growing space exploitation technology expertise, interest, and activity.

FUTURE SUMMARY

Four problems are slowing the Army's exploitation of space:

1. Limited space exploitation doctrine.
2. Missing user requirements.
3. Poor acquisition strategy coordination and implementation.
4. Reluctant acceptance or rejection by senior Army leaders of operational space exploitation missions and roles.

Lack of doctrine, lack of a complete space architecture, and missing user requirements prevent the ground service from specifying how best to fight with space assets and in what evolutionary priority these assets should be acquired.

The third problem exists because the service has not assigned in a systemic manner primary responsibility for simultaneously coordinating and conducting R&D of:

- The three space exploitation capabilities (i.e., enhance the ground force, space control, and force application).
- The three acquisition strategy tasks (i.e., get receivers, get processors, and influence future space system design).
- The numerous space technologies (i.e., reconnaissance-surveillance-and-target-acquisition (RSTA), position/navigation (Pos/Nav), military-man-in-space (MMIS), communications, TMD, ASAT, ABM, etc.).

Furthermore, Army space exploitation materiel developers have not devised implementation plans to "get receivers, get processors, and influence systems designs and operations." It is therefore difficult for the Army to initiate and then maintain a rapid and efficient space exploitation acquisition effort. R&D responsibility weaknesses impede necessary coordination to reduce the cost of space exploitation research and hinder effectively leveraging ongoing technology programs. Disjointed and overlapping R&D responsibilities tend to support an unsystematic development of Army-tailored space exploitation capabilities and piecemeal advocacy of separate space capabilities. It is currently more likely that commodity managers or major Army commands will harmfully compete among themselves for limited Army and DoD funds and support. Thus, developing a coherent, integrated space exploitation acquisition effort and gaining necessary funding from 1990 Defense Acquisition Board (DAB) or Defense Review Board (DRB) reviews appears unlikely unless this problem is overcome.

The first three problems, plus the high cost of space exploitation systems, fuel senior Army leaders' reluctance to actively declare what operational space exploitation missions, such as conducting continental ABM defense, it is willing to forgo or actively pursue.

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FIGURES

PHOTOGRAPH DESCRIPTIONS

ACRONYMS AND ABBREVIATIONS

AA	Anti-Aircraft
AACS	Army Airways Communication System
AAF	Army Air Forces
ABM	Anti-Ballistic Missile
ABMA	Army Ballistic Missile Agency
ABMDA	Army Ballistic Missile Defense Agency
ACANS	Army Communication and Administration System
ADC	Air Defense Command (originally Army, later USAF)
AEC	Atomic Energy Commission
AFSPACECOM	USAF Space Command
ALB	AirLand Battle (Army doctrine)
ALB-F	AirLand Battle Future (Army doctrine concept)
AMC	Army Materiel Command
AMR	Atlantic Missile Range
AOA	Airborne Optical Adjunct (Army project)
AOMC	Army Ordnance Missile Command
ARGMA	Army Rocket and Guided Missile Agency
ARPA	Advanced Research Projects Agency (later DARPA)
ASAS	All Source Analysis System
ASAT	Anti-Satellite
ASAT JPO	ASAT Joint Program Office (Army)
ASI	Army Space Institute
ASIS	Army Space Initiative Study
ASTRO	Army Space Technology Research Office
ATACMS	Army Tactical Missile System
ATCCS	Army Tactical Command and Control System
ATM	Anti-Theater Missile
BDE	Brigade (Army maneuver unit)
Bell Labs	Bell Laboratories (developer of Nike air defense system)
BM/C3	Battle Management/Command, Control & Communications
BMD	Ballistic Missile Defense
BMDATC	Ballistic Missile Defense Advanced Technology Center

BMDC	Ballistic Missile Defense Center
BMDO	Ballistic Missile Defense Organization
BMDSCOM	Ballistic Missile Defense System Command
CAC	Combined Arms Center
CBRS	Concept-Based Requirements System
CECOM	Communications-Electronics Command (Army)
CIA	Central Intelligence Agency
CIT	California Institute of Technology (see JPL)
COE	Corps of Engineers
CONAD	Continental Air Defense Command
CONUS	Continental United States
CS	Combat Support
CSOC	Consolidated Space Operations Centers
CSS	Combat Service Support
C3	Command, Control & Communication
DA	Department of the Army
DAB	Defense Acquisition Board
DARPA	Defense Advanced Research Projects Agency
DCA	Defense Communication Agency
DCS	Defense Communications System
DEW	Directed Energy Weapon
DIA	Defense Intelligence Agency
DIV	Division (Army maneuver unit)
DMA	Defense Mapping Agency
DoD	Department of Defense
DRB	Defense Review Board
DSCS	Defense Satellite Communication System
EAC	Echelons Above Corps
EASTT	Experimental Army Satellite Tactical Terminals
ENSURE	Expedite, Non-standard, Urgent Requirement for Equipment
ERIS	Exoatmospheric Reentry-Vehicle Interceptor Subsystem
EV88	Experimental Version 1988
EW	Electronic Warfare
FAADS	Forward Area Air Defense System
FFAR	Folding Fin Aircraft Rocket

FLAGE	Flexible Lightweight Agile Guided Experiment
FOBS	Fractional Orbiting Bombardment System
FOC	Full Operating Capability
FOG-M	Fiber Optics Guided-Missile
FY	Fiscal Year
GBL	Ground-Based Laser
GBR	Ground-Based Radar (formerly TIR)
GEO	Geosynchronous orbit
GEODSS	Ground-Based Electro-Optical Deep Space Surveillance
GPS	Global Positioning System
HAWK	Homing All the Way Killer (anti-aircraft missile)
HEDI	High Endoatmospheric Defense Interceptor
HOE	Homing Overlay Experiment
ICBM	Intercontinental Ballistic Missile
IDCS or IDCSP	Initial Defense Communication Satellite Program
IGY	International Geophysical Year 1957–1958
INF Treaty	Intermediate-range Nuclear Forces Treaty
IOC	Initial Operating Capability
IRBM	Intermediate Range Ballistic Missile
JCS	Joint Chiefs of Staff
JPL	Jet Propulsion Lab
JSC	Johnson Space Center
JSTARS	Joint Surveillance Target Attack Radar System
JRDB	Joint Research and Development Board
KEW	Kinetic Energy Weapon
KMR	Kwajalein Missile Range
LAW	Light Anti-tank Weapon
LEO	Low Earth Orbit
LoAD	Low-Altitude Defense (concept)
LWIR	Long Wavelength Infrared
MAAG	Military Assistance Advisory Group
MET SAT	Meteorology Satellite
MHV	Miniature Homing Device
MICOM	Missile Command (Army)
MILSTAR	Military Strategic, Tactical and Relay (satellite)

MMIS	Military-Man-in-Space
MRBM	Medium-Range Ballistic Missile
MLRS	Multiple Launch Rocket System
MX	Missile Experimental (i.e., USAF PeaceKeeper)
NACA	National Advisory Committee for Aeronautics
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NAVSPACECOM	U.S. Naval Space Command
NCA	National Command Authority
NORAD	North American Aerospace Defense Command
NPB	Neutral Particle Beam
NRL	Naval Research Laboratory
NSA	National Security Agency
NSC	National Security Council
NSDD	National Security Decision Directive
NSDM	National Security Decision Memorandum
NTM	National Technical Means (of verification)
OAMP	Optical Aircraft Measurement Program
OCO	Office Chief of Ordnance
ODCSOPS	Office, Deputy Chief of Staff, Operations and Plans
PAO	Public Affairs Office
PAR	Perimeter Acquisition Radar (Army Safeguard)
PATRIOT	Phased-Array Tracking to Intercept of Target, missile
PE	Program Element (R&D budget & work package)
PEO	Program Element Office/Organization
PBW	Particle Beam Weapon
PMR	Pacific Missile Range
Pos/Nav	Position Navigation (satellite)
R&D	Research and Development
RSA	Redstone Arsenal
RSTA	Reconnaissance, Surveillance, and Target Acquisition
ROC	Required Operational Capability
RV	Reentry Vehicle (a nuclear warhead)
SA/BM	Systems Analysis/Battle Management
SAC	Strategic Air Command

SAFSCOM	Safeguard System Command
SAINT	Satellite Interceptor
SALT	Strategic Arms Limitation Treaty
SATCOMA	Satellite Communication Agency (Army)
SATKA	Surveillance, Acquisition, Track and Kill Assessment
SCF	Satellite Control Facility (at Sunnyvale, CA)
SCORES	Signal Communication by Orbital Relay Equipment Satellite
SDI	Strategic Defense Initiative
SDIO	Strategic Defense Initiative Organization
SECDEF	Secretary of Defense
SENSCOM	Sentinel System Command
SIE	SATKA Integrated Experiment
SLBM	Submarine-Launched Ballistic Missile
SLKT	Survivability, Lethality, and Key Technologies
SOF	Special Operations Forces
SPADOC	Space Defense Operations Center
SPADATS	Space Detection and Tracking System
SRHIT	Small Radar Homing Intercept Technology
STRATCOM	Strategic Communication Command (Army)
STS	Space Transportation System (Space Shuttle)
SYNCOM	Synchronized Communication Network
TACMS	Tactical Missile Systems
TACSATCOMP	Tactical Satellite Communications Program
TENCAP	Tactical Exploitation of National Capabilities
TIR	Terminal Imaging Radar (Army project)
TIROS	Television and Infrared Observation Satellite
TMD	Theater Missile Defense
TOC	Tactical Operations Center
TOW	Tube-launched Optically guided Weapon
TRADOC	Training and Doctrine Command
TTR	Target Tracking Radar
USA	United States Army
USAF	United States Air Force
USAISC	U.S. Army Information Systems Command
USARSPACE	U.S. Army Space Command

USARV	U.S. Army Republic of Vietnam
USASDC	U.S. Army Strategic Defense Command
USSPACECOM	U.S. Space Command (Unified)
WAC-Corporal	Without Altitude Control—Corporal (Army missile)
WET SAT	Weather, Enemy, Terrain sensing satellite (author's term)
VHSIC	Very High-Speed Integrated Circuit
WSMR	White Sands Missile Range
WSPG	White Sands Proving Grounds
WW2	World War Two

I. INTRODUCTION

BACKGROUND

Since 1945, the U.S. Army has been directly involved with research and development (R&D) and application of space systems. During the last six to seven years, a debate has gone on within the Department of Defense (DoD) on whether it is appropriate for the Army to be increasingly involved in space and, if so, how should the Army exploit space.

Supporters and opponents have strongly argued their positions because of the important national security, service integration, and budget implications of having the Army control and/or acquire high-technology strategic defense and satellite systems. It would be reasonable then to expect our policy decisionmakers and senior operational commanders, who influence the outcome of this debate, to be knowledgeable of the Army's historical role and utilization of space. This knowledge would allow them to understand where the Army has been, where it is now, and where it ought to go in exploiting space. Such historical perspective and insight should directly contribute to making wise defense decisions.

However, few DoD personnel, classified documents, or open literature sources can explain the chronology of the U.S. Army in space beyond 1961. Typically, sources of information about the Army's involvement with space state words to the effect: "The Army was the preeminent pioneer in space from 1945 up through 1961 and has unfortunately lost that capability."[1] These observers display a narrow focus on space events and provide little comment on how major non-space events or international threats influenced the Army to be active or not active in pursuing space capabilities. These sources do not or cannot explain from a system viewpoint why the Army as a dynamic organization reduced its efforts in space booster and satellite launches. Also, these sources simultaneously address, at most, only four of the following eight subjects:

1. The national security threat confronting America.
2. National and DoD defense and space policy.
3. U.S. space organizations.

[1]LTC C. L. Bryant, *The U. S. Army in Space: Past, Present, Future*, Industrial College of the Armed Forces, Ft. McNair, Washington, D.C., May 1987, p. i.

4. Boosters and missiles.
5. Satellites.
6. Ground stations, including communication networks and ground radar surveillance and tracking of satellites.
7. Anti-ballistic missile (ABM) defenses.
8. Anti-satellite defenses.

PURPOSE

Therefore, the purpose of this paper is threefold. First, it is intended to coherently describe the evolution of the Army's exploitation of space in response to an emerging post-World War II (WWII) Soviet threat while complying with national policy and organizational directives. This study will include an organizational explanation of how the Army became America's preeminent pioneer in reliable booster development, launch, and space operations by 1960; how the Army's space exploitation efforts were constrained between 1961 and 1976; and recovery actions since 1976 that the Army has implemented to exploit space. The second purpose is to inform the Army, that part of the Department of Defense (DoD) that works daily on space matters, military service school students, and the space research community of the full spectrum of the Army's past and current exploitation of space. This effort will be accomplished by providing a chronology of decisions and events, from 1907 through 1989, which have shaped the Army's exploitation in the technological areas of: ballistic missiles, satellites, early warning radars, ground stations, anti-satellite (ASAT) defenses, ABM defenses, theater missile defenses (TMD), and tactical missiles. Finally, the third purpose is to assist DoD and Army leaders in making better informed analysis and decisions about how the Army ought to exploit space in the future.

BASELINE DEFINITIONS

My research has revealed that the word "space" is a value-laden word, such as "blind date." With either word, you are not sure what you will get when you start talking about it. For example, some people, when the word space is used, think only of U.S. reconnaissance satellites, others think of manned shuttles and deep space probes, and some think of ABM defenses. Therefore it is important for the reader to understand that the term "space" is defined by this author as the region above the earth beginning at the altitude that permits the lowest achievable circular orbit with a period of 87-1/2 minutes

for a satellite to complete one revolution of the planet.[2] This altitude is approximately 94 statute miles above sea level. The term "exploitation of space," as employed in this paper, means gaining deterrence, crisis management, or warfighting benefit for a ground force commander from signals, beams, or missiles, whether those benefits come from an asset orbiting the earth or from a signal, beam, or missile temporarily transiting space.

Under these definitions, the spectrum of exploitation includes enhancing ground operations by observing the environment and the enemy, as well as communicating critical time-sensitive information. Also included is controlling space by preventing enemy observation or communication use of space and/or preventing enemy transit of space. Effectively applying force by delivering timely targeting information to friendly ground forces or delivering force from space completes the range of space exploitation options. Figure 1 and the following examples characterize the exploitation spectrum.

Enhancing ground force operations by observation and communication

- During peace or war, Army ground terminals capture and use signals from enemy, third-party, or friendly satellites. These picture or spectral signals could be communication, intelligence, position/navigation, map/terrain, or weather data.
- A theater commander launches on demand satellites or pop-up sensors to directly support his forces where previously launched national/strategic satellite network coverage is unavailable or has been disrupted by enemy action.
- A U.S. military assistance group provides operational level and tactical level weather and intelligence information to a friendly third world country.

Controlling space by preventing enemy use or transit of space

- Ground forces employ kinetic or beam ASAT weapons to eliminate threatening satellites from observing, monitoring, or engaging U.S. launch and ground facilities, launched missiles, satellite constellations, or maneuver forces.

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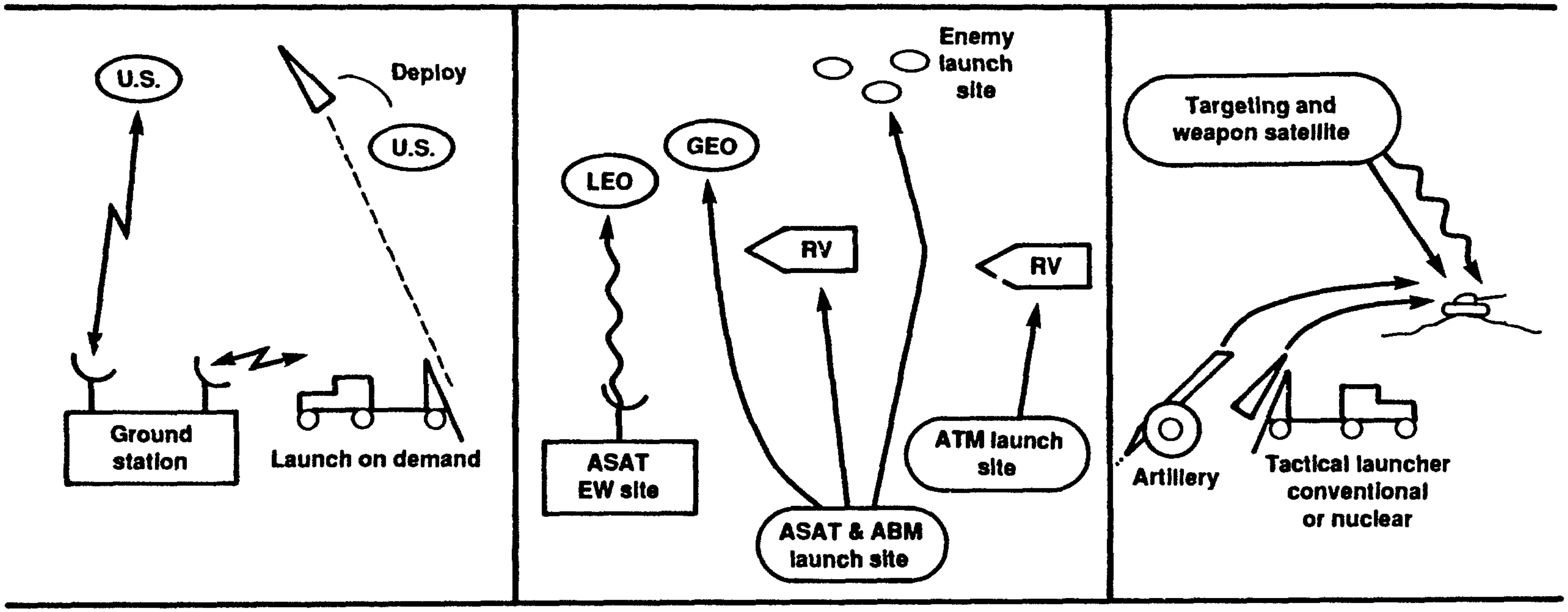
[2] *Space Systems Handbook for Staff Planners and Operators*, U.S. Space Command, Center for Aerospace Analysis, Peterson AFB, CO, 1988, p. 2.



- Enhance ground operations by
  - Observation
  - Communication
- Example R&D
  - Strategic, theater and tactical ground stations/receivers
  - Integrated intelligence and TOC
  - Recon, Met, WET, Pos/Nav, communications satellites
  - Launch on demand capability

- Control space by
  - Preventing enemy use of space
  - Preventing enemy transit of space
  - Assured U.S. access
- Example R&D
  - ASAT sensors, weapons, and BM/C3
  - ABM sensors, weapons, and BM/C3
  - TMD sensors, weapons, and BM/C3
  - Electronic warfare

- Apply force by
  - Improving speed and accuracy of ground weapons
  - Delivering force from space
- Example R&D
  - Targeting satellite
  - Weapon delivery satellite
  - Integrated intelligence and TOC

Fig. 1—The Army space exploitation spectrum

- Ground forces employ electronic warfare to jam, disrupt, or spoof threatening satellites from observing, monitoring, or engaging U.S. launch and ground facilities, launched missiles, satellite constellations, or maneuver forces.
- ABM nuclear, kinetic, or beam weapons protect the continental United States and its allies from nuclear attack.
- Theater anti-theater missile (ATM) units accurately engage inbound enemy missiles based upon satellite-supplied early warning and updated tracking data.

Applying force by delivering ground targeting information from space

- Theater artillery and missile units accurately pinpoint and destroy massed enemy armor, artillery, missile, supply, or headquarters units with conventional smart munitions based upon information delivered from targeting satellites.
- Theater forces employ intermediate-range ballistic missiles (IRBMs) which transit through space to strike a target deep in the enemy's rear battle zone.
- Destructive kinetic or beam force is delivered from a space platform against enemy communications nodes.

The reader should note that the author's exploitation definition differs for two reasons from the U.S. Space Comand and the U.S. Air Force definition of military space functions. First, the organization definitions lack emphasis on Force Application in terrestrial operations and placing "steel" on terrestrial targets. Second, the organization definitions unnecessarily separate anti-satellite operations and ballistic missile defense operations into the two different military functions of Space Control and Space Force Application when both of these operations or missions employ nearly identical technology and procedures to accomplish the goal of preventing enemy use or transit of space while ensuring U.S. access.

RESEARCH DATA SOURCES

Review of available space and missile history reports written prior to 1989 revealed "stovepipe" chronologies which reflected only a particular technology development. No chronology or history existed which presented a simultaneous view of developments in national policy, missiles, warheads, satellite payloads, long-range radars,

communication and tracking ground stations, ASAT defenses, or ABM defenses. This paper attempts to provide this systemic chronology as related to the U.S. Army based upon the following sources:

- Information supplied by eleven command historical offices (1 DoD office, 6 Army offices, 2 National Aeronautics and Space Administration (NASA) offices, and 2 Air Force offices).
- Extensive reading of open literature and government documents published in the period 1946 through 1989.
- Numerous interviews with and briefings from action officers assigned to DoD and Army organizations involved with space policy, doctrine development, and operations. Example organizations tapped for information were: the Department of the Army (DA), the U.S. Space Command (USSPACECOM), the U.S. Army Space Command (USARSPACE), the U.S. Army Space Institute (ASI), the U.S. Army Strategic Defense Command (USASDC), the Army Materiel Command (AMC), the Global Positioning Satellite (GPS) project office, and the PATRIOT project office.
- Document review comments provided by the Office, Deputy Chief of Staff for Operations and Plans (ODCSOPS), ASI, USARSPACE, USASDC, and from the U.S. Army Missile Command (MICOM)
- Three and one-half years' experience while assigned to the USASDC, including weekly involvement with Strategic Defense Initiative Organization (SDIO) managers and acquisitions efforts.
- Fifteen months experience while assigned to USSPACECOM.

Because of the breadth of this paper, numerous footnotes would disrupt the reading and understanding of many of the paragraphs. Therefore, only one footnote per paragraph was used. Multiple references supporting a paragraph are listed in chronological order in the footnote section of the paper.

ORGANIZATION

The remainder of this paper is organized as follows. Sections II, III, and IV provide a trend analysis of the interrelated threat, national security policy, historical, technological, and operational events which occurred during the period 1907 through mid-1989. Section II addresses the Army's apogee in space exploitation. Section III

discusses the Army's perigee in space exploitation. And Sec. IV explains the Army's recovery efforts to exploit space. Section V presents constraints to future Army progress in exploiting space.

The trend analysis sections may be read in two ways. If the reader is interested in the overall synergistic trends of Army space exploitation during a single or multiple period, then the Apogee, Perigee, and Recovery sections should be read in their entirety. However, if the reader is interested only in the Army's exploitation of one space technology, then the specific technology paragraphs should be read in sequence beginning with the Apogee section and ending in the Recovery sections while ignoring the other technology paragraphs. For example, if the reader wanted to learn the chronological history of Army ballistic missile efforts, then the long-range missile paragraph found in Sections II, III, and IV should be read in that order.

The appendixes provide six chronologies which the reader may separately interpret or refer to while reading the trend analysis sections. The six chronologies are:

A—Space and Missile Policy and Organization Chronology

B—Long-Range Artillery/IRBM/ICBM Missile Chronology

C—Satellite Chronology

D—Ground Station, Radar, and Communication Chronology

E—Anti-Aircraft/Missile/RV and ASAT Chronology

F—Small Tactical Missiles and Vietnam War Chronology

CHRONOLOGY OVERVIEW

The chronology of Army exploitation of space has four recognizable stages: apogee, perigee, recovery, and future. Figure 2 portrays these stages with representative major events or decisions influencing the Army's space involvement and capabilities.

Apogee can be looked upon as the "good old days" when the Army was publicly seen as the preeminent pioneer in space technology and application, including reliable ballistic missile boosters, satellites, global military communication ground stations, radars, and high-altitude anti-aircraft missiles. Perigee can be described as the "silent years" when the Army's space exploitation interest and activity were significantly constrained. Recovery is the phase the Army is now undergoing. The Army's space exploitation destination, in terms of specific Army-tailored missions and system operation, is currently being defined.

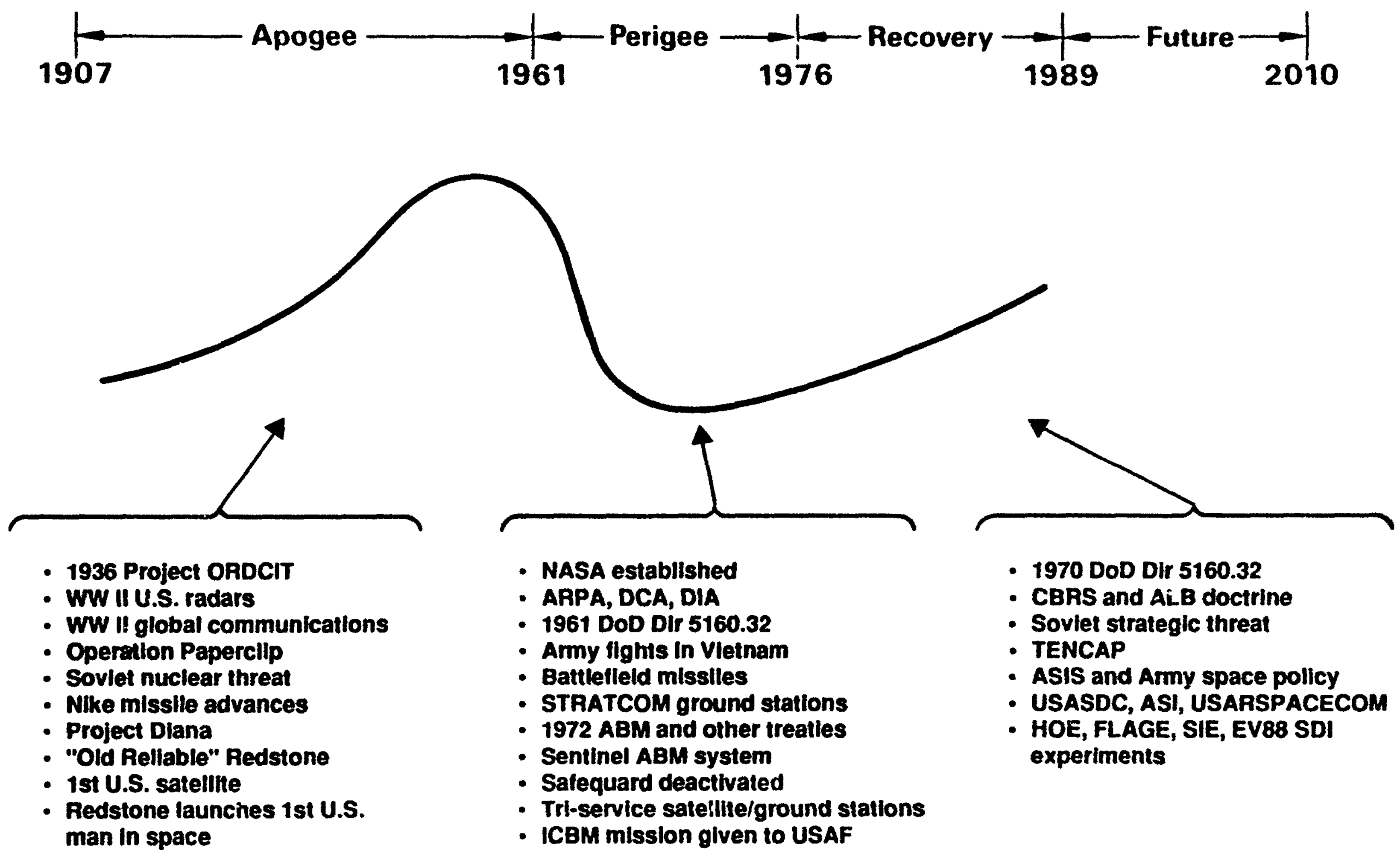


Fig. 2—Army space exploitation chronology phases

Although Fig. 2 shows the phases as sequential, the actual division is not so clean. Overlapping influences occurred and will be explained below. Even so, the model is helpful in conceptualizing and understanding the major stages of Army involvement in space.

II. APOGEE PHASE, 1907–1961

WWII: PRIOR TECHNOLOGY AND COMBAT EXPERIENCE

The seeds of the Army's involvement in space sprouted prior to WWII. From 1907 through 1941, the Army's Signal and Ordnance Corps conducted R&D on emerging technologies which could help the ground service better perform critical warfighting functions. These functions were gathering intelligence and terrain information, communicating messages, and delivering munitions upon the enemy. The technologies developed were the airplane, the radio, radar, and rockets.

Specifically, on 1 August 1907, the airplane entered military service with the establishment of the Army Signal Corps Aeronautical Division. Subsequently in 1908, the War Department made the Army Signal Corps responsible for development and operation of all military aircraft based upon the belief that aircraft would primarily be used for reconnaissance and message carrying.

In January 1918, the U.S. Signal Corps commissioned Dr. Robert H. Goddard, later referred to as the father of modern rocketry, to develop military rockets and study long-range solid-propellant bombardment rockets. Dr. Goddard and C. A. Hickman successfully demonstrated on 10 November 1918 a bazooka-type recoilless rocket at Aberdeen Proving Ground. The signing of the WWI Armistice on 11 November 1918 curtailed any further funding of Dr. Goddard's research for the Army.[1]

During the 1930s and 40s, the Signal Corps diligently worked at developing mobile communication devices for mechanized forces and airplanes, as well as at developing signals intelligence capabilities. In 1936, the first unified U.S. investigation of rockets began with Army Project ORDCIT. Army Ordnance contracted with the California Institute of Technology (CIT) to conduct basic research on solid- and liquid-propellant rockets with the intent to move from development of test vehicles to a guided missile. In the field of radar, by 1937, research had sufficiently matured for Col. W. Blair, Directory of Army Signal Corps Laboratories at Fort Monmouth, to patent the first military radar.[2]

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[1]Ruth Jarrell and Mary T. Cagle, *History of the Plato Antimissile Missile System*, ARGMA, Redstone Arsenal, AL, 1961, pp. 7–8.

[2]*Development of the CORPORAL: The Embryo of the Army Missile Program*, Monograph #4, Army Ballistic Missile Agency, Redstone Arsenal, AL, April 1961, p. xiii; P. H. Satterfield, *Historical Monograph Army Ordnance Satellite Program*, Army Ballistic Missile Agency, Redstone Arsenal, AL, 1 November 1958, p. 40; *A History of the Signal Corps 1860–1975*, U.S. Army Communications Command, Ft. Huachuca, AZ, pp. 10–11; *Air Force Magazine*, "USAF

During WWII, the Army's aircraft, signal, and radar R&D were significantly applied. Massive amounts of aerial photos were taken and processed by ground support personnel to supply intelligence to maneuver commanders. By 1945, the Signal Corps Army Communication Service operated the largest, global/long-haul, unified, military communication network developed to date. It was composed of both the Army Communication and Administration System (ACANS) and the Army Airways Communication System (AACS) used to assist aircraft in global navigation. The Signal Corps during the war also developed, produced, and fielded major advances in multichannel signal communication, automatic encryption, and synchronization. Furthermore, virtually all the important radar equipment employed by the United States in combat up to the end of WWII, including long-range anti-aircraft, early warning and tracking radar, and the B29's radar, was developed under the Signal Corps. Early radar experience included the failure to believe Army radar warnings of the Japanese attack on Pearl Harbor, early warning of enemy bomber attacks against European and Pacific deployed units, and the detection and tracking of German V-2 missile attacks against England.[3]

As WWII progressed, the military recognized current and emerging post-war threats. The fire bombings of Hamburg and Tokyo and the U.S. atomic bombing of Japan clearly exposed the vulnerability of cities to long-range, high-altitude, mass destruction attacks. Allied WWII anti-aircraft (AA) guns were experiencing difficulty engaging high-altitude bombers and fast fighters. The emergence of the German jet airplane heralded supersonic aircraft. The German V-2 missiles used to attack London in 1944 and 1945 revealed the vulnerability of cities and ground forces to long-range artillery missiles.

Members of the U.S. Army began considering the methods and developing the military means needed to protect America from these vulnerabilities. Obviously, America would need to be armed with long-range bombers and missiles. Also, America would have to protect herself by developing and deploying an effective radar-guided, AA defense able to destroy high-altitude, supersonic threats.

The Army's missile R&D response was guided by the Ordnance Rocket Branch established in 1943 for central management of rockets similar to other arms and

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Facts and Figures," May 1987, p. 79; K. R. Coker and C. E. Rios, *A Concise History of the U.S. Army Signal Corps*, U.S. Army Signal Center, Ft. Gordon, GA, September 1988, pp. 21 and 23.

[3]W. E. Burrows, *Deep Black: Space Espionage and National Security*, Random House, New York, 1986, pp. 48–51; *A History of the Signal Corps*, U.S. Army Communications Command, Ft. Huachuca, AZ, pp. 11–12; Coker and Rios, pp. 21–24.

munitions. Army Ordnance, in May 1944, signed a $3.3 million dollar contract with CIT/Jet Propulsion Lab (JPL) to study rocket propulsion and the development of long-range surface-to-surface guided missiles. Later that year, in November, Army Ordnance contracted for Project ORDCIT to perform high-altitude anti-aircraft missile research. These contracts led CIT/JPL to conduct 24 solid-propellant, private rocket flight tests at Fort Irwin, California during 1944. And that same year, the Army established the White Sands Proving Grounds (WSPG) in New Mexico for future rocket and missile research. The Army effort to develop missiles was demonstrated by conducting the first successful U.S. developmental flight of a "large" (10-inch diameter or larger) liquid-propellant rocket in September 1945—Without Altitude Control-Corporal (WAC-Corporal), at WSPG.[4]

Meanwhile in Europe, Colonel H. N. Toftoy and Major J. P. Hamill executed Operation Paperclip to ensure the United States benefited from WWII German rocket expertise. During May and June of 1945, these Army officers removed hundreds of German and Austrian rocket experts, 100 nearly complete V-2 rockets, and 300 train carloads of rocket material and documents from Nordhausen in the Harz mountains. The Army completed removing the German V-2 experts and materiel just prior to the Russian occupation of that sector. By December 1945, 120 German rocket engineers, including Dr. Wernher von Braun, had arrived at Fort Bliss, Texas, to work for the Army at the newly established Ordnance R&D Rocket Sub-Office at Fort Bliss. Major Hamill was assigned as director of the Sub-Office. By May of 1948, a total of 492 Project Paperclip German/Austrian rocket specialists had arrived in America and were distributed as follows: 177 to the Army, 205 to the Air Force, 72 to the Navy, and 38 to the Commerce Department but under Army control.[5]

Therefore, by the end of 1945, the Army had significant experience in the following areas:

- Aerial intelligence gathering, processing, and dissemination.
- Signals intelligence gathering, processing, and dissemination.

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[4]J. W. Bullard, *History of the Redstone Missile System*, U.S. Army MICOM, Historical Monograph #AMC-23M, Redstone Arsenal, AL, 15 October 1965, p. 3; H. B. Joiner and E. C. Jolliff, *The Redstone Arsenal Complex in its Second Decade, 1950–1960*, Historical Division, Army Missile Command, Redstone Arsenal, AL, 28 May 1969, p. 39; J. V. Nimmen, *NASA Historical Data book, 1958–1968*, Vol. 1, NASA, Washington, D.C., 1976, p. 353; Corporal Monograph #4, p. xii; Satterfield, pp. 23, 39–40.

[5]Satterfield, pp. 20–38; Nimmen, p. 353; Joiner, p. 3.

- Development and operation of global, long-haul communication ground stations, including encryption and synchronization.
- AA and anti-missile air defense early warning.
- Solid- and liquid-propellant rocket propulsion development.

1945–1960 THREAT, NATIONAL POLICY, AND DoD ORGANIZATION

Immediately after WWII, the climate to fund missile research was extremely poor. Much of the public felt the United States had the strongest military force in the world and need not fear anyone, since it was the only country with atomic bombs. Simultaneously, the government was concerned with controlling the budget while demobilizing, reestablishing a consumer economy, and helping rebuild Europe. The military, however, felt that the WWII fighting force needed to be refurbished. Thus, new conventional weapon systems, such as jet interceptors, intercontinental bombers, tanks, and submarines, began competing for portions of the U.S. military budget.[6]

It was under these conditions that the rocket supporters within the services came to the government attempting to gain a share of the R&D budget for their new technologies. And Dr. Vannevar Bush, chief of the War Department's Office of Scientific R&D, was not impressed with the claims by the services of future potential military benefit of missiles and satellites. In December 1945, Dr. Bush testified that it would be impossible for many years to develop a 3000-mile high-angle rocket. Dr. Bush, throughout the 1940s, maintained that the military was unable to provide an acceptable argument which would convince him that missiles or satellites could cost-effectively accomplish any warfighting requirement better than available aircraft or other ground systems.[7]

For the next 45 years, the Army and other services would continually face a utility challenge when requesting approval and funds to conduct missile and space-related research. The utility challenge had five parts:

1. Show how the new Army capability, during deployment and operation, will not destabilize U.S.-USSR relations.
2. Show how the new capability overcomes a new vulnerability or is beneficial to performing traditional or assigned Army missions.

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[6]W. A. McDougall, *The Heavens and the Earth*, Basic Books Inc., New York, 1985, pp. 132–134.

[7]R. L. Perry, *Origins of the USAF Space Program*, USAF Systems Command Historical Publication Series 62-24-10, Vol. V, 1961, pp. 14–20.

3. Show why the Army should perform this research instead of another government agency or service.
4. Show that the new capability/asset/system is cost-effective compared with alternative ground-based systems.
5. Show there is sufficient technological maturity to actually perform as claimed.

When the ground service could satisfactorily answer these questions, its research efforts prospered. Often the Army would be successful when international events appeared to threaten U.S. national security. But Army supporters of missile and satellite technology would repeatedly have difficulty predicting and portraying realistic benefits to the ground service of these emerging technologies. This was the same problem that supporters of the airplane, tank, machine gun, and radar had prior to those systems' becoming an accepted capability for successful modern day warfare.

As the practical "czar" of military R&D during the 1940s, Dr. Bush effectively kept missile funding to a minimum and ensured no "large" rocket programs were funded until 1950. For example, in December 1946, the government accepted his advice and reduced the Fiscal Year (FY) 1947 missile budget from $29 million to $13 million, thus eliminating 20 of 28 missile programs. This cutback included eliminating the Air Force's only ballistic missile program, but it did continue the Army and Navy's missile research. Specifically, the Army was funded to continue its Hermes C1 long-range ballistic missile studies, WSPG V-2 launches, and design work on the Bumper missile.[8]

Counter to Dr. Bush's views, the War Department Equipment Board (known as the Stillwell Board because it was chaired by Army General J. W. Stillwell) reported in May 1946 on its findings regarding the needs of the post-WWII Army. The board identified the national security need for the United States to not be technologically surprised in the future. It also predicted a prominent role for tactical missiles in future warfare while calling for careful research of the specific missiles needed.[9]

Congress meanwhile attempted to reorganize the War Department to better serve the country. It passed the National Security Act in 1947, establishing the Department of

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[8] H. B. Joiner and E. C. Jolliff, *The Redstone Arsenal Complex in its Second Decade, 1950–1960*, Historical Division, Army Missile Command, Redstone Arsenal, AL, 28 May 1969, p. 2; Perry, pp. 14–20.

[9] P. B. Stares, *The Militarization of Space, U.S. Policy 1945–1948*, Cornell Press, Ithaca, NY, 1985, p. 27; "USAF Facts and Figures," May 1987, p. 79.

Defense and the U.S. Air Force as a separate service. In 1948, the first Secretary of Defense, J. V. Forrestal, negotiated specific missions and roles for each of the three major military services. The Army received primary responsibility for conducting land operations, for AA defense of the continental United States, and for providing overseas occupation and security forces. The Air Force received jurisdiction over strategic air warfare, air transport, and combat air support of the Army. The Navy was responsible for sea operations and the Marine Corps.[10]

Prior to the passage of the National Security Act of 1947, the Army and Navy attempted to coordinate development of missile and satellite assets through the aeronautical Joint R&D Board (JRDB). After passage of the Act, three services competed to develop space assets by gaining funding approval from the DoD JRDB. The Navy in 1947 petitioned the JRDB for approval over U.S. satellite development, but withdrew its claim in 1948 after USAF General Vandenberg issued a policy statement on the primacy of USAF space interests. He stated that satellites were a logical extension of strategic air power and should be the responsibility of the air service.[11]

Unfortunately for America, the cold war gradually emerged and then escalated when the United States confronted expansionist communist Russia during the Berlin Crisis of June 1948. The Russian threat continued to evolve as demonstrated 3 September 1949 when an American B29 weather plane detected radioactivity in the Pacific off Soviet territory. This hard evidence indicated that the first Soviet nuclear explosion had occurred between 26 and 29 August. More worrisome to the United States was learning in October–December 1953, through intelligence sources, that the Soviets were well along in development of an intercontinental ballistic missile (ICBM). Now America faced an opponent whose geography allowed it to hide its most sensitive military secrets far behind its borders, whose closed society restricted access to information by other intelligence means, who had the capability and willpower to shoot down most aircraft imaging platforms, and who was rapidly developing the technological capability to attack the United States with nuclear mass destruction weapons from thousands of miles away.[12]

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[10]M. Matloff (ed.), *Army Historical Series American Military History*, Office of the Chief of Military History, U.S. Army, Washington, D.C., 1969, p. 532; Stares, p. 27.

[11]Perry, pp. vii and 24–25; Stares, p. 28.

[12]S. Ramo, *The Business of Science: Winning and Losing in the High-Tech Age*, Hill and Wang, New York, 1988, p. 78; Q. M. Florini, "The Opening Skies: Third Party Imaging Satellites and U.S. Policy," *International Security*, Harvard/MIT, Vol. 3, No. 2, Fall 1988, p. 109; Matloff, pp. 542–544; Burrows, pp. 64–65.

This situation triggered a major shift in American national security policy toward development of long-range offensive missiles, air defense missiles, and advanced reconnaissance capabilities. A crash program to develop an ICBM was initiated.

This overall shift in policy is best represented by the government's actions in 1955. In February, the government's Technical Capability Panel (Killian Committee) recommended that the United States:

- Continue rapid development of an ICBM.
- Continue rapid development of an intermediate-range ballistic missile (IRBM) and extend its range to 1500 miles.
- Develop an advanced high-altitude reconnaissance aircraft (the U-2).
- Develop a reconnaissance satellite.[13]

In accepting these recommendations the President assigned the highest national development priority to the missile programs, with the stipulation that the IRBM development could not interfere with the ICBM effort.[14]

Also by 1955, the Eisenhower Administration recognized the future national security requirement to observe Russia from space. The Administration actively worked to ensure the freedom of satellite transit over and observation of any point on earth while reducing the Soviet inclination to prevent such passage and observation by attacking orbiting satellites. Accordingly in May 1955, the National Security Council (NSC) ruled that the Army Redstone missile and the USAF Atlas could not be used to launch the first U.S. satellite. The Administration wanted the first U.S. satellite to be the Vanguard, a non-military scientific satellite, in order to present U.S. space efforts as being peaceful.[15]

But in 1957, the U.S. public experienced a technological Pearl Harbor. In August, the Soviets launched the world's first successful ICBM. On 4 October, the Soviets orbited the world's first satellite, Sputnik I. Another technological shock occurred on 3 November 1957 when the Soviets orbited the 1120-pound Sputnik II. This launch

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[13]J. M. Grimwood and F. Strowd, *History of the Jupiter Missile System*, AOMC History and Reports Control Branch, Redstone Arsenal, AL, 27 July 1962, pp. 2, 5; Stares, p. 31; Burrows, p. 71.

[14]Joiner, p. 74.

[15]COL A. Downey, *The Emerging Roles of the U.S. Army in Space*, National Defense Press, Washington, D. C., 1985, p. 4; Satterfield, pp. 54–55; M. E. Davies, and W. R. Harris, *RAND's Role in the Evolution of Balloon and Satellite Observation Systems and Related U.S. Space Technology*, The RAND Corporation, R-3692-RC, September 1988, p. 63.

demonstrated the Soviet capability of delivering heavy nuclear warheads against targets thousands of miles outside their borders. Despite the Eisenhower Administration's attempts to downplay the severity of the situation, both the public and Congress perceived these Soviet accomplishments as reflecting a quantum advantage over the U.S. missile and space capability.[16] This was the type of situation the Stillwell Board had warned the government to avoid.

The public's concerns were further exacerbated when Democratic Senator L. B. Johnson's Senate Armed Services Committee in January 1958 investigated why the USSR beat the United States into space and learned:

- That the Army had volunteered to orbit a satellite prior to 1957.
- That in May 1956 the Secretary of Defense's Special Assistant for guided missiles had refused the Army's request for the Jupiter-C to be a backup alternate to the Vanguard program.
- That the Army's three-stage Jupiter-C had lofted a nose cone 682 miles into space 20 September 1956. [17]

While the public and congressional uproar was exploding, DoD worked to get an American satellite into space. On 4 October 1957, when Sputnik I was orbited, MG J. B. Medaris, commander of the Army Ballistic Missile Agency (ABMA), briefed Secretary of Defense McElroy at Redstone Arsenal on how soon the Army could launch a satellite. No definitive action was taken until 8 November, when after another Vanguard launch failure, the President directed the Army to orbit a satellite by March 1958. Eighty-four days later, on 31 January 1958, the ground service restored U.S. and free world confidence in our ability to compete with the Russians by launching the first American operational satellite, Explorer I, aboard a modified Redstone missile.[18]

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[16]N. L. Johnson, *Soviet Military Strategy in Space*, Jane's Publishing Co., 1987, p. 17; A. Holm, "Why Are the Soviets Against Missile Defense—Or Are They?" *Naval War College Review*, Vol. 40, No. 3, Seq. 319, Summer 1987, p. 54; D. J. Johnson, *The Evolution of U.S. Military Space Doctrine: Precedents, Prospects, and Challenges*, PhD dissertation, UCLA, Los Angeles, CA, December 1987, p. 17; MAJ Roe and MAJ S. Wise, "Space Power Is Land Power: The Army Role in Space," *Military Review*, January 1986, p. 66.

[17]Nimmen, p. 3; Satterfield, pp. 56–59; Grimwood, p. 8-1.

[18]*Chronology of the ABMA, February 1956–December 1960*, ABMA Monograph #5, Army Ordnance Missile Command, Redstone Arsenal, AL, September 1961, p. 25; Bullard, p. 143; Satterfield, p. 61; Downey, p. 6.

Three major problems still confronted the Eisenhower Administration and Congress in 1958. First, the nation's splintered space efforts needed to be effectively organized and focused to exploit space. Second, no civilian space organization existed to conduct non-military space work. Third, the agency with the most experienced space experts, with the best space development facilities, and with the most reliable booster system was the Army. Many people in the Administration, Congress, DoD, and the Air Force perceived satellite booster development, satellite launch, operation, and tracking as inappropriate missions for the ground service.[19]

Therefore, 1958 became the year that several major U.S. national security, space policy, and organization decisions were made. In January, Senator Johnson's Armed Services Committee adopted 17 recommendations for improved space organization, management, and increased missile and space funding. On 7 February, DoD established the Advanced Research Projects Agency (ARPA) as a single agency to approve and direct the military and civil space programs. On 13 February, NSC directive 5802/1 was issued recognizing the need for continental defense, the importance of satellite defense, and the need for vigorous R&D in these two areas. Also in February, the President directed the Central Intelligence Agency (CIA) to develop reconnaissance satellites separate from the USAF, thus initiating Project Corona. In June, NSC directive 5814/1 (U.S. Policy on Outer Space) was issued recognizing the national security threat to the United States from Soviet space achievements and the necessity to immediately develop reconnaissance satellites. On 29 July, Congress approved the National Aeronautics Space Act creating NASA to manage the U.S. non-military space programs including exploration of space.[20]

A significant change in the conduct of strategic warfare emerged during the apogee phase. Airplane air power was drastically reduced by missile power, which would come to be the dominant strategic nuclear delivery system after 1957.[21] Once the United States and USSR gained the capability to orbit satellites over and deliver long-range ICBMs onto each other's homeland, both became strategically vulnerable to nuclear destruction. Thus, in space, U.S. military activity or an asset transiting or orbiting in space could interfere with, damage, or destroy Soviet capital satellites or otherwise push the Soviets

[19]Joiner, p. 74; *Chronology of the ABMA*, pp. 11, 29.

[20]*Historical Origins of George C. Marshall Space Flight Center (MSFC)*, NASA, Huntsville, AL, December 1960, p. 16; Nimmen, pp. 3–4; Stares pp. 38, 44, 49; Burrows pp. 104–105.

[21]B. Brodie, *Strategy in the Missile Age*, The RAND Corporation, Princeton University Press, 1959, pp. 152–153, 200–218, 239, 269, 360–361.

into a hostile nuclear response. This fact created a "national security" challenge. After 4 October 1957, whenever the Army and other military services requested to develop space exploitation capabilities, they had to show how this new capability, during deployment and operation, would not destabilize U.S.-USSR relations.

POST-WWII TECHNOLOGY PROBLEMS

It was within the above described international threat and national policy environment that the Army pioneered missile, air defense, ASAT defense, and satellite technology advances. In 1945, the Army rocket supporters were confronted with a set of basic missile technology problems which had to be solved before the WWII rocket would be transformed into an effective military weapon. The primary problem was that a reliable, heavy lift booster was needed by a nation before it could loft a satellite into space or deliver a warhead against an enemy.

A top-level summary of the long-range artillery missile technology problems can be described as they appear along a missile flight. The first problem is the need for ground handling, test equipment, and facilities capable of safely launching a missile. Next is needed a reliable booster composed of a lightweight sturdy structure able to carry the payload, propellant, and motor. A controlled flow of a high-impulse solid- and liquid-propellant must be ignited and burnt without catastrophically exploding. Liquid-propellant, additionally, must be reliably delivered to the motor. In order for the missile to fly high enough or far enough, large boosters and/or multiple stages are necessary. If stages are used, they must successfully separate and the next stage motor must ignite in flight. As the missile's payload or warhead reenters the earth's atmosphere, it must be protected from destruction by aerodynamic heating. For the payload or warhead to hit a short-range target, accurate ground guidance is needed. For the payload or warhead to hit a target thousands of miles away, accurate on-board guidance is needed.

The top-level summaries of the anti-aircraft, anti-missile, and ASAT technology problems are the same as the long-range artillery missile problems, except reentry is replaced by the need to successfully detect, track, and home on high-altitude supersonic targets. This additional problem was basically a radar technology problem.

The top-level satellite problems are the same as long-range artillery missile problems with the following additional needs: achieve desired altitude in space, eject the satellite into orbit, provide in-space power for satellite operations, conduct reconnaissance, and reliably communicate to earth stations.

During the period 1945 through 1963, the U.S. Army developed the free world's initial pioneering solutions to the above set of missile, air defense, and satellite problems. Figure 3 summarizes major Army technology "firsts" in relation to the technology problem set.

1945–1961 ARMY LONG-RANGE MISSILE DEVELOPMENTS

The Army's post-WWII long-range missile capability was founded upon three efforts which came together in 1945: the Army's previous Project ORDCIT research, the wedding of JPL to the Army via large R&D contracts leading JPL to deed 31.5 acres with facilities in California to the Army, and employing 177 German V-2 experts to work on Army rocket research centered at WSPG. The Army/JPL/von Braun and General Electric team conducted basic solid- and liquid-propellant, single, and multistage missile research from 1946 through 1950 in California and at WSPG. Fifty-two V-2 flight tests were conducted by the von Braun team as an adjunct to long-range artillery during the latter half of the decade. The Army team placed telemetry on the V-2 missiles, something the Germans did not do during WWII. Spin stabilization was developed with the WAC-Corporal in 1948, as well as two-stage capabilities with the 1949 Bumper rocket tests.[22]

In 1950, the Army consolidated its missile development efforts at Redstone Arsenal (RSA) by moving the WSPG research efforts and other Army rocket research to Alabama. This action brought missile munitions under the Army "arsenal" concept, thus better ensuring timely development and adequate availability of rockets for the government.[23]

That same year the Chief of Ordnance directed RSA to study a surface-to-surface, 2000-pound payload missile able to fly 500 nautical miles. The missile which grew out of this effort was later named Redstone. In 1951, Colonel Toftoy as Chief of the Rocket Branch, Office Chief of Ordnance, increased the Redstone missile payload weight to 6900 pounds, sufficient to handle existing atomic warhead weights, thus forcing the Redstone's range to be decreased to 200 miles.[24]

By 1953, the Army had successfully launched the first U.S. heavy ballistic missile, the Redstone, from Cape Canaveral. During 1954 the ground service fielded the first atomic warhead missile battalion (Honest John) and deployed to Europe the first overseas

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[22]Satterfield, pp. 23, 39; Bullard, pp. 3 and 11; "Corporal Monograph #4," pp. xii–xiv; Nimmen, p. 353; Joiner, p. 39.

[23]Downey, pp. 1–3; Nimmen, pp. 11, 353; Joiner, p. 40; Grimwood, pp. 7–8.

[24]Joiner, p. 40; Grimwood, p. 1; Bullard pp. 35–36.

Problem	Army Solution
Launch reliable missile • Need safe ground handling and test equipment, launch facilities • Need lightweight, sturdy structure • Need rocket motor that ignites and does not explode • Need controlled high impulse propellant delivery to motor • Need controlled thrust • Need on-board telemetry for rapid R&D	• 1936 Army Project ORDCIT, first unified U.S. investigation of rockets • 1944–1956 missile development series: Private, WAC-Corporal, V-2, Bumper, Corporal, Redstone, and Jupiter • 1945 first U.S. "large" thrust rocket motor tests • 1945 first successful U.S. flight of a large, liquid propellant rocket, the WAC-Corporal • 1949 first missile telemetry from space • 1953 first successful heavy ballistic missile launch, the Redstone • 1953 first use of transistors in missiles, significantly improves missile reliability • By 1958 press dubs Redstone missile "Old Reliable"
Long-range nuclear artillery • Deliver heavy nuclear warhead deep into enemy territory • Safely handle nuclear warheads • Provide field-safe, solid propellant missile	• 1945 activate first Guided Missile battalion at Ft. Bliss, Texas • 1947 first successful flight of U.S. tactical, surface-to-surface Corporal missile • 1950 Corporal first U.S. missile approved as an atomic warhead carrier • 1954 Honest John deployed as first tactical nuclear weapon • 1955 Army initiates solid fuel Sergeant missile program • 1957 first successful free world IRBM flight: Jupiter missile
Multi-staging • Need sufficient height or range to reach target • Need successful stage separation • Need successful in-flight motor ignition	• 1949 first successful U.S. 2-stage rocket flight: Bumper rocket • 1956 first successful U.S. 3-stage missile flight: Jupiter missile achieved 682 mile altitude—3,335 mile range • 1957 first successful free world IRBM flight: Jupiter missile achieved 1,147 mile range • 1957 Army begins Juno (Saturn) development effort
Reentry • Prevent aerodynamic heating destruction of payload, human, or warhead • Retrieve reconnaissance payload from space	• 1947 Army flies Blossom Project V-2 missile for Air Material Command testing cannister ejection and parachute recovery • 1950 Army completes V-2 test firings including Albert monkey flights • 1957 first successful U.S. nose cone recovery from space, proving ablation principle; technique later used on U.S. manned flight program: Jupiter RS-40 • 1959 first successful U.S. live recovery of animals sent into space

Fig. 3—Early technology and threat problems versus Army solutions

Problem	Army Solution
Guidance/accuracy • Achieve stable flight • Achieve ground-to-air missile guidance • Achieve on-board missile guidance • Accurate warhead delivery	• 1944-1956 missile development series: Private, WAC-Corporal, V-2, Bumper, Corporal, Redstone, and Jupiter • 1948 first use of spin rocket aerodynamic stabilization • 1953 first successful U.S. missile with on-board inertial guidance: Redstone missile
Satellite • Boost satellite into space, achieving orbital altitude • Remove shroud and eject payload into orbit • Provide in-space power • Conduct reconnaissance from space • Provide reliable space-to-ground communication	• 1956, Jupiter launched nose cone to a 682 mile altitude • 1958 Army orbited first free world earth satellite, Explorer I, and other Explorer satellites • 1958 Signal Corps develops first successful space flight solar converters: Vanguard I • 1958 Signal Corps develops first military satellite communication package: Scores • 1958 first successful U.S. lunar probe: Pioneer III • 1959 second U.S. lunar probe and first U.S. sun satellite: Pioneer IV • 1960 Signal Corps develops the Tiros I satellite producing first TV signals from space • 1961 first and second U.S. astronauts in space launched aboard modified Redstone missiles
Bomber and missile air defense • Prevent intercontinental bomber-delivered nuclear attack • Prevent ICBM-delivered nuclear attack • Detect, track, and home anti-missiles onto supersonic, high-altitude target	• 1951 first successful U.S. anti-aircraft radar tracking and intercept of high-altitude aircraft by Nike-Ajax missile • 1954 first continental air defense units deployed: Nike-Ajax • 1958 first successful intercept of a high-altitude, supersonic target missile by Nike-Hercules missile • 1960 first successful intercept of a ballistic missile by Nike-Hercules • 1962 first successful intercept of an ICBM by Nike-Zeus
ASAT • Prevent enemy satellite observation or nuclear attack • Detect, track, and home missile to target satellite	• 1962 first successful U.S. ground-launched ASAT intercept by a point in space: DB-15B Zeus missile • 1963 first successful U.S. ground-launched ASAT intercept of an actual satellite: MudFlap #5/Redstone missile

Fig. 3—continued

ballistic missile battalion (Corporal). In September 1955, the Army recommended that DoD use the Redstone/Jupiter as the basis for the 1500-mile IRBM that the Killian Committee recommended be developed. Achieving the IRBM range was now feasible, since the Atomic Energy Commission's 1953 technology breakthroughs were significantly reducing the weight of nuclear warheads.[25]

The Secretary of Defense in September 1955 approved the Army Jupiter and USAF Thor IRBM development programs. By 1 February 1956, the Army established ABMA at RSA with special acquisition authority to ensure rapid IRBM development. ABMA responded with the first successful Jupiter-A launch on 14 March. Remarkably, on 20 September 1956, the Army's Jupiter-C #RS-27 launched a nose cone along a trajectory with a height of 682 miles into space and a down-range distance of 3335 statute miles. In November of that year, Secretary of Defense Wilson fixed the Army and Air Force missile responsibility. The Army would develop missiles having ranges of 200 miles or less and the USAF would develop missiles with ranges greater than 200 miles. Subsequently, the Army finished development of the Jupiter, trained USAF Strategic Air Command missile battalion personnel at RSA, and delivered the first Jupiter to the Air Force by August 1958 for overseas deployment and operation by the air service.[26]

The Army conducted significant satellite booster research during the late 1950s. In April 1957, the ABMA/von Braun team had begun design studies for a 12,000-pound payload booster titled Juno. This was the nation's first booster solely designed for space investigation. In October 1958, ARPA expanded ABMA's Juno V booster effort to include the complete missile; it was later renamed Saturn. In December a Juno II launched the first successful U.S. lunar probe.[27]

In response to the 1957 Soviet technological space surprises, Congress created NASA on 29 July 1958. NASA was initially formed by absorbing government civil and military space-related organizations and/or space projects into the agency. The Army made some of the most significant contributions to NASA up through 1961, including

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[25]F. Gibney, "The Missile Mess," *Harper's Magazine*, January 1969, p. 1; Nimmen, p. 379; Joiner, p. 42; "Corporal Monograph #4," pp. xvii–xviii.

[26]E. Faikowski, *SATURN Illustrated Chronology, April 1957 through June 1964*, NASA Historical Office, MSFC, Redstone Arsenal, AL, p. 6; Joiner, pp. 23, 58, 74–76, 118; Perry, pp. 13–14; Satterfield, p. 216.

[27]D. S. Akens, *SATURN Illustrated Chronology, April 1957 through April 1968*, NASA Historical Office, MSFC, Redstone Arsenal, AL, 20 January 1971, p. 1; E. Stuhlinger, "Army Activities in Space—A History," *IRE Transactions on Military Electronics*, Vol. Mil-4, No. 2-3, April-July 1960, p. 66; Joiner, p. 3; Grimwood p. 13-2; Origins MSFC, p. 18.

major space development facilities at RSA which were redesignated as the Marshall Space Flight Center. On 3 December 1958, the Army transferred to NASA its Redstone launch vehicle program, its Explorer satellite program, and all JPL contract functions, facilities, and land, along with 2328 rocket and satellite specialists. In January 1959, NASA requested eight Army Redstone-type missiles to launch the first U.S. astronauts into space during Project Mercury. In November 1959, the Army transferred its 1.5 million pound thrust Saturn missile project to NASA. During March through 1 July 1960, ABMA transferred its Development Operations Division, including the 150 German scientists and engineers of the von Braun team, 3900 ABMA personnel, and 2500 skilled missile and satellite technicians and craftsmen. Finally, in 1961, NASA launched the first U.S. astronaut, Alan B. Shephard, into suborbital flight aboard a modified Army Redstone missile.[28] Even today, civilian and military personnel in the Huntsville area can be heard to proudly declare how the "Northern Alabama Space Agency" or how the "Army/NASA" team led the nation into space.

While the liquid-propellant Jupiter, Juno/Saturn, and NASA efforts transpired, the Army worked on developing a solid-propellant replacement to the Redstone. On 7 January 1958, the Secretary of Defense authorized the Army effort to continue. And by February 1960, the Army conducted the first successful firing of the Pershing.[29]

1945–1961 ARMY SATELLITE DEVELOPMENTS

Army satellite efforts from 1945 through 1961 can be described as falling into three efforts: initial. Explorer, and other satellite work.

Initial Satellite Efforts

The Army's initial satellite efforts began 25 June 1954 when ABMA's Dr. von Braun presented the Office of Naval Research with a proposal for using a Redstone main booster for a joint service launching of an earth satellite. A joint service effort was needed because the sparse space R&D budgets did not supply enough funds for one service to launch a satellite effort as well as work on boosters. Later that year, Dr. von Braun published the first true engineering thesis for a low earth satellite using existing Army hardware. The thesis was titled "A Minimum Satellite Vehicle." In January 1955,

[28]Dept of the Army, FM 100-18 (Draft), *Space Support For Army Operations*, June 1988, p. 1-1; MG J. B. Medaris, CG AOMC, "The von Braun Team," Army Ordnance Missile Command Information Paper, Redstone Arsenal, AL, 1 August 1959, Introduction; Nimmen, pp. 4, 11, 380; Akens, p. 6; Perry, pp. 18–19; "Origins MSFC," p. 21; Downey, pp. 7–8.

[29]Joiner, pp. 59, 78, 122; *Chronology of the ABMA*, p. 32.

the Navy agreed to the joint effort and Project Orbiter was initiated. But the effort was rejected by the Secretary of Defense's office because of the Administration's policy that the first American satellite be the non-military Vanguard project.[30]

ABMA's missile team felt that the Vanguard effort, using less proven booster technology than the Redstone, was highly unlikely to orbit a satellite on schedule. The Army wanted to continue satellite work but had been prevented from doing so by the Secretary of Defense. So the ground service gained DoD approval to conduct 12 nose cone tests in support of the Jupiter IRBM program. This approval opened the door for the Army to continue satellite-like research launches.[31]

In May 1956, the Army offered the Jupiter-C as an alternative or backup to the Vanguard but was again rejected. So, the Army quietly continued its successful nose cone/satellite launch research. On 20 September 1956, the Army lofted Jupiter-C missile #RS-27 to an altitude of 682 miles into space. In April, ABMA published the Janus report indicating the feasibility of a reconnaissance satellite. In August, the Army recovered the first object from space, a scale model nose cone which survived reentry by employing the fiberglass and resin ablation principle. The Army clearly had the reliable capability to orbit a satellite in 1956, 1957, or early 1958 but was restricted from doing so.[32]

Over a year later, on the day Sputnik I was launched, ABMA's MG Medaris briefed the Secretary of Defense on how soon the Army could orbit a satellite.[33] The Sputnik flights and Vanguard failures forced the Administration to accept the Army's offer. Because of the ABMA's open booster research and quiet nose cone/satellite research, the Army was able to launch the free world's first earth satellite 84 days after receiving go-ahead approval.

Explorer Satellite Efforts

Seven Explorer satellites were launched by the Army, with three failing to achieve orbit. The Explorer I satellite made initial detection of the Van Allen radiation belts.

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[30] "Historical Facts of ABMA Entry Into the Space Program," Army Ordnance Missile Command summary fact sheet CAA 19930/231-61, 1 October 1958, p. 1; Satterfield, pp. 53–55; Stares, p. 33.

[31] *Aviation Week*, "Army Gaining Vital Space Assignments," 16 January 1958; Satterfield, p. 54.

[32] W. Ley, *Rockets, Missiles, and Space Travel*, Viking Press, New York, 1958, p. 488F; *Chronology of the ABMA*, p. 18; Grimwood, p. 8-1; Joiner, p. 77; Nimmen pp. 379–380; Burrows, pp. 87–88.

[33] *Chronology of the ABMA*, p. 23.

Explorer III was the first U.S. satellite to store information on tape and play it back when interrogated from the ground. Explorer IV took measurements of the sun and the nuclear effects created during the Project Argus high-altitude nuclear explosions. After transfer of the Explorer satellite program to NASA, the Army launched and orbited its last Explorer satellite, VII, on 13 October 1959.[34]

Other Satellite Efforts

During 1958 through 1960, the Army directly contributed to the development of other meteorological, TV reconnaissance, communication, and lunar probe-type satellites.

Meteorological satellite work occurred in early 1958. By March of 1958, the Signal Corps had completed designing and building the solar converters for the NASA satellite Vanguard I. These converters were the first successful flight-tested solar power sources developed by the United States. By February 1959, the Army Signal R&D laboratories had developed the complete electronic package for Vanguard II to conduct infrared scanning of earth cloud cover.[35]

TV reconnaissance work also occurred in 1958. During July through November 1958, ABMA proposed and received approval from DA to conduct a television feasibility demonstration project originally proposed by the Janus reconnaissance satellite study. On 13 November 1959, the Army began TV reconnaissance flight tests and launched the first flying TV aboard a Redstone missile in March 1960. The Signal Corps simultaneously developed for NASA the Television & Infrared Observation Satellite (TIROS I & II). TIROS I provided the first satellite TV signals from space after it was orbited in April 1960; TIROS II followed in November.[36]

Communication satellite work began when the Signal Corps developed for ARPA the communication package for the first successfully orbited military satellite, named Signal Communication by Orbital Relay Equipment Satellite (SCORES). This satellite provided the first voice communication from space and President Eisenhower sent his 1958 Christmas message to the world via SCORES. On 29 February 1960, ARPA established the ADVENT 24-hour, equatorial synchronous, military communication

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[34]Stuhlinger, p. 66; Medaris, Significant Achievements page; Origins MSFC, p. 16; Roe and Wise, p. 8; Joiner, p. 122.

[35]*A Concise History of Ft. Monmouth, New Jersey*, U.S. Army Communication-Electronics Command Historical Office, Ft. Monmouth, NJ, July 1985, pp. 41–42; A History of the Signal Corps, p. 15.

[36]H. B. Joiner, "Historical Information Summary, Comment #2," Historical Division, Army Missile Command, Redstone Arsenal, AL, 6 November 1963; A History of the Signal Corps, pp. 15–16; Bullard, pp. 146–147.

satellite program. The Army was directed to begin developmental work on the satellite communication equipment while the USAF was to handle booster and spacecraft development. The Army Courier IB satellite was launched on 4 October 1960, and subsequently stored and then transmitted on command messages to earth. This satellite established the feasibility of relaying all types of facsimile messages by satellite.[37]

Lunar probe satellite work began 27 March 1958 after the Secretary of Defense assigned ABMA the mission to launch two lunar probes utilizing Jupiter/Juno missiles. On 6 December 1958, ABMA/JPL launched for NASA the first successful U.S. lunar probe, Pioneer III, which traveled 63,580 miles toward the moon. And on 3 March 1959, the Army launched the Pioneer IV lunar probe, which became the first free world satellite to orbit the sun.[38]

1944–1958 ARMY AIR AND SPACE DEFENSE DEVELOPMENTS

Adding to the Army's space application capability during the period 1944 through 1960 was the developmental work on the Nike Ajax, Nike Hercules, and Nike Zeus continental defense, surface-to-air missile systems.[39]

Air defense efforts began in February 1944 when Army Ordnance and the Army Air Forces (AAF) initiated development work on a surface-to-air, high-altitude, supersonic, guided missile which later became Nike I. In November of that same year, the Army let the Hermes contract to General Electric to study high-altitude anti-aircraft missiles. Project Nike followed in February 1945 when Army Ordnance let the Nike Ajax missile contract and air defense feasibility study to Bell Laboratories (Bell Labs) and assigned RSA responsibility to supervise and coordinate the effort. By September 1946, the first test firing of an experimental, solid-propellant Nike R&D booster was conducted at WSPG. Research continued on this system, which used ground radars to simultaneously track an enemy target and home the defense missile onto the target. On 27 November 1951, a Nike Ajax made the first successful U.S. intercept of an aircraft flying at 300 mph at 33,000 feet at a range of 15 miles. In December of 1953, the Army's

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[37]T. Brandt, *The Military Uses of Space*, National Defense University Press, 1985, p. 83; *Space and Missile Systems Organization: A Chronology, 1954–1979*, USAF Space Division History Office, Los Angeles, CA, p. 77; History of Ft. Monmouth, p. 43; A History of the Signal Corps, pp. 16, 27; *Chronology of the ABMA*, p. 55.

[38]Stuhlinger, p. 66; Medaris, p. 18; *Chronology of the ABMA*, p. 38.

[39]Downey, pp. 65–66.

Anti-Aircraft Command's Nike Ajax became operational, and was deployed on 20 March 1954 to defend the Washington, D.C.-Baltimore area.[40]

In May 1952, the Ordnance Department initiated a feasibility study for extending the Nike Ajax range up to 100 miles altitude. RSA was assigned R&D responsibility for this Nike Hercules study. In March 1955, the Army initiated the Nike II study to determine a common air defense system against all future (1960s and 1970s) high-altitude bomber and ICBM threats. In 1958, Nike Hercules missiles were deployed throughout the continental United States and overseas to Formosa. Nike Hercules capabilities were demonstrated 19 November 1958, when it made the first successful U.S. intercept of a high-altitude, supersonic target missile (60,000 feet and 1500 mph). Additional Nike Hercules capabilities were demonstrated on 3 June 1960 when the air defense missile made the first intercept of a ballistic missile (Corporal) above White Sands Missile Range (WSMR), New Mexico.[41]

During February 1957, the Ordnance Department directed RSA and Bell Labs to develop the Nike Zeus anti-missile/ICBM system based on an improved nuclear-tipped Nike Hercules using long- and short-range radars. In early 1959, DoD approved the Nike Zeus test program to launch target missiles from Johnston Island and test Nike Zeus missiles from Kwajalein Missile Range (KMR). This plan was modified by DoD the next year so that Atlas missiles fired out from Vandenberg AFB would be used as target vehicles.[42]

The first successful test flight of the Nike Zeus anti-missile missile occurred during August 1959 at WSMR. During 1960, the Army initiated its Reentry Measurements Program to establish radar characteristics of nuclear reentry warheads. On 28 May 1961, the Nike Zeus Target Tracking Radar (TTR) successfully tracked an ICBM launched at the Atlantic Missile Range (AMR). Then in June 1961, the Army authorized Bell Labs to proceed with design of a prototype electronically steered, phased-array radar. And on 14 December 1961, the first full system demonstration of the Nike Zeus was conducted, including the intercept of a Nike Hercules by a Nike Zeus.[43]

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[40]Origins MSFC, pp. 3, 6; Joiner, pp. 40–41.

[41]*Kwajalein Field Station, ABM Research and Development at Bell Laboratories*, Army Ballistic Missile Defense Systems Command, Contract DAHC60-71-C-0005, October 1975, p. 23; *Project History, ABM R&D at Bell Laboratories*, Army Ballistic Missile Defense Systems Command, Contract DAHC60-71-C-0005, October 1975, pp. I-1 thru I-6; *Army Rocket and Guided Missile Agency Historical Summary, 1 July–31 December 1958*, AOMC, Redstone Arsenal, Al; Joiner, pp. 43, 118.

[42]Joiner, pp. 26 and 47; Project History, pp. I-15 through I-22.

[43]Holm, pp. 55–57; Kwajalein, p. 59; Project History, pp. I-23, I-24, I-33.

Army space defense efforts in the late 1950s centered around determining the effects of high-altitude nuclear explosions upon low earth satellites. On 22 March 1957, the Secretary of Defense chose the Redstone missile for launching high-altitude nuclear detonations for the Atomic Energy Commission (AEC) during Operation Hardtack. Later that year the Army published its space program recommending that a national security requirement existed for an ASAT system and proposed to DoD that a modified three-stage, nuclear-tipped Nike Zeus be used as such a weapon. In July 1958, ABMA launched the Explorer IV satellite which measured Project Argus high-altitude nuclear explosions and also launched Operation Hardtack with Redstone missile #50 which detonated a nuclear warhead at an altitude of 47.5 miles. In May 1961, the Army Nike Zeus TTR demonstrated its ability to detect low earth satellites by tracking the Echo satellite, which had a radar cross section of 28.5 db/sq-meter, at a distance of 1400 miles.[44]

APOGEE SUMMARY

By the end of 1945, the Army had significant R&D and combat experience in the following areas:

- Aerial intelligence gathering, processing, and dissemination.
- Signals intelligence gathering, processing, and dissemination.
- Development and operation of global, long-haul communication ground stations, including encryption and synchronization.
- Anti-aircraft and anti-missile air defense early warning.
- Solid- and liquid-propellant rocket propulsion development.

During the period 1945 through 1961, the U.S. Army's solid- and liquid-propellant missile booster propulsion, guidance, warhead handling, nose cone survival, satellite, and air defense R&D "firsts" solved a majority of space technology problems. This R&D effort directly led to getting America into space and represented a major contribution to national security. The apogee of Army involvement in space was demonstrated by successful applications, such as development of reliable boosters and orbiting the first

[44]Joiner, p. 74; *Chronology of the ABMA*, pp. 17, 45; Stares, pp. 49 and 117; Stuhlinger, pp. 66; Project History, p. I-23; Information provided by Dr. Allen E. Fuhs, Professor Emeritus at the Naval Post-Graduate School, Monterey, CA, 31 October 89.

U.S. satellite, along with national recognition and dedicated service interest in exploiting space technology during the years 1958 through 1961.

However, by the mid-1940s, the Army began to face a utility and national security challenge whenever the ground service requested DoD approval and funds to conduct space exploitation or related research. The challenge had five parts:

1. Show how the new Army capability, during deployment and operation, will not destabilize U.S.-USSR relations.
2. Show how the new capability overcomes a new vulnerability or is beneficial to performing traditional or assigned Army missions.
3. Show why the Army should perform this research instead of another government agency or service.
4. Show that the new capability/asset/system is cost-effective compared with alternative ground-based systems.
5. Show there is sufficient technological maturity to actually perform as claimed.

When the ground service could satisfactorily address these concerns, its research efforts prospered.

PHOTOGRAPHS OF EVENTS

The next 27 pages include photographs provided by the U.S. Army MICOM Historical Office of events described in this document.

Plate 1—Dr. Wernher von Braun, center, is pictured in 1956 with Maj. Gen. John B. Medaris, commander, U S. Army Ballistic Missile Agency, and with Maj. Gen. Holger N. Toftoy, Redstone Arsenal commander.

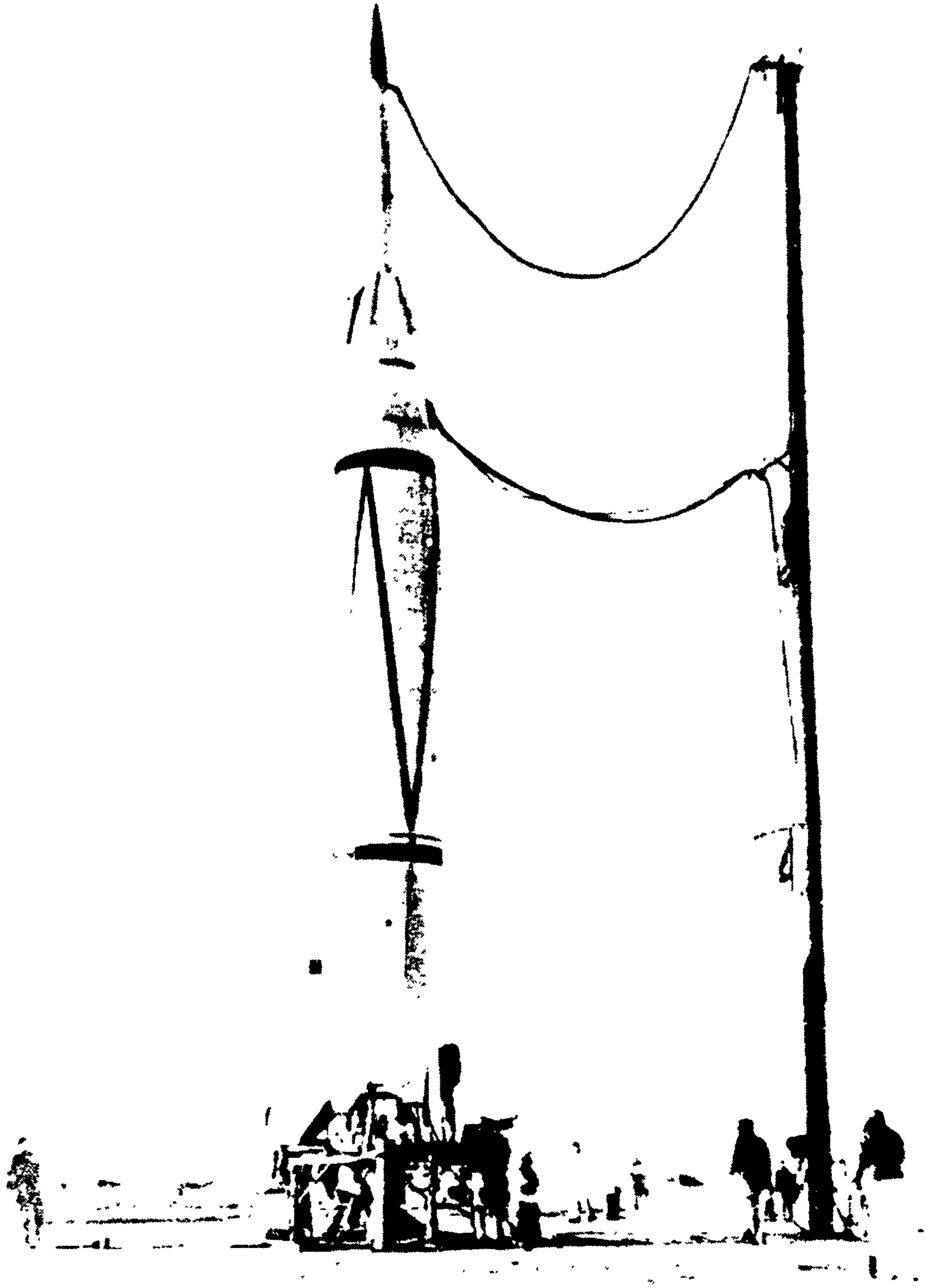


Plate 2—A 1949 Bumper WAC rocket takes on fuel in preparation for a test launch at White Sands Missile Range.

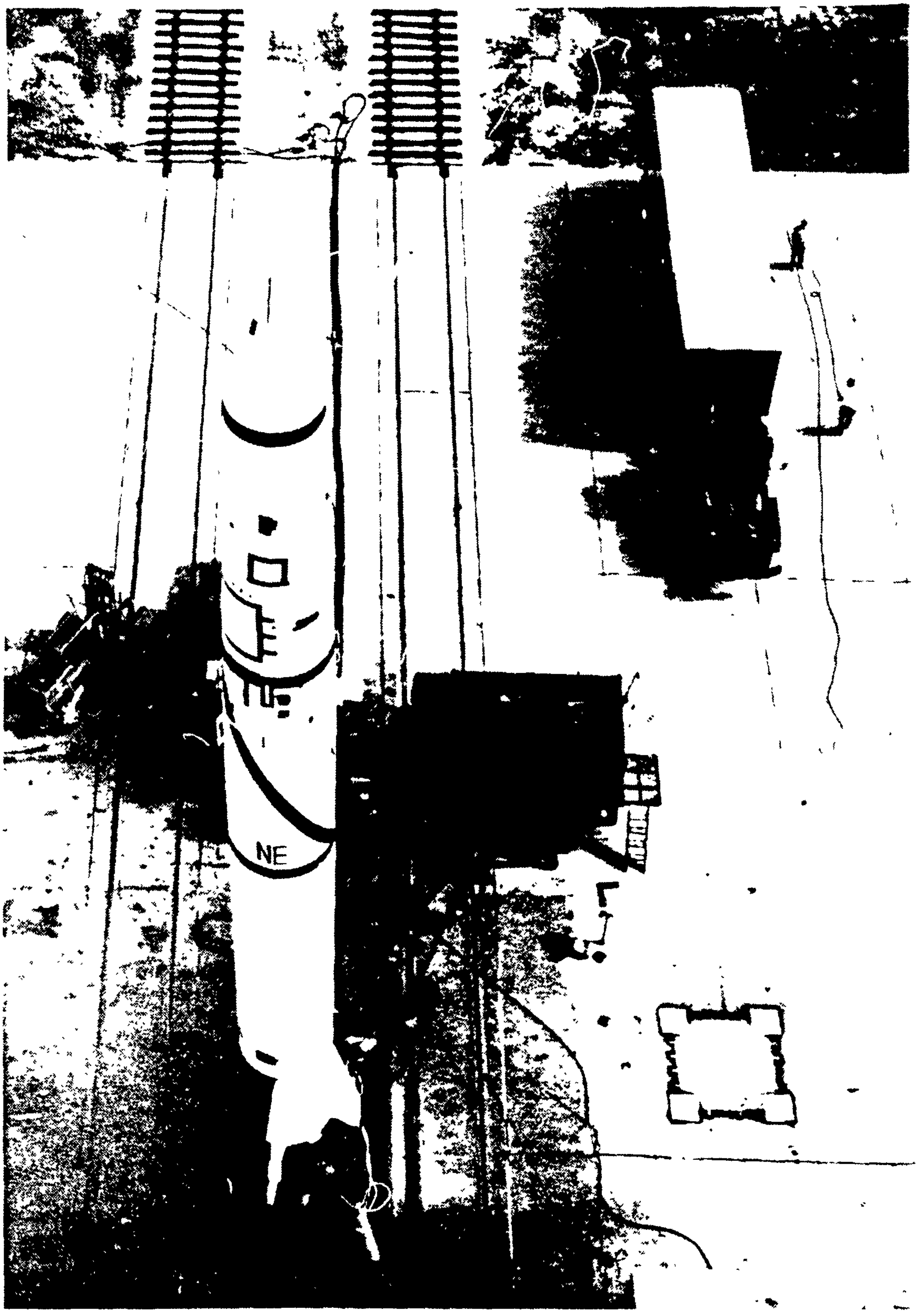


Plate 3—An early Redstone missile is poised on the launch pad at Cape Canaveral.

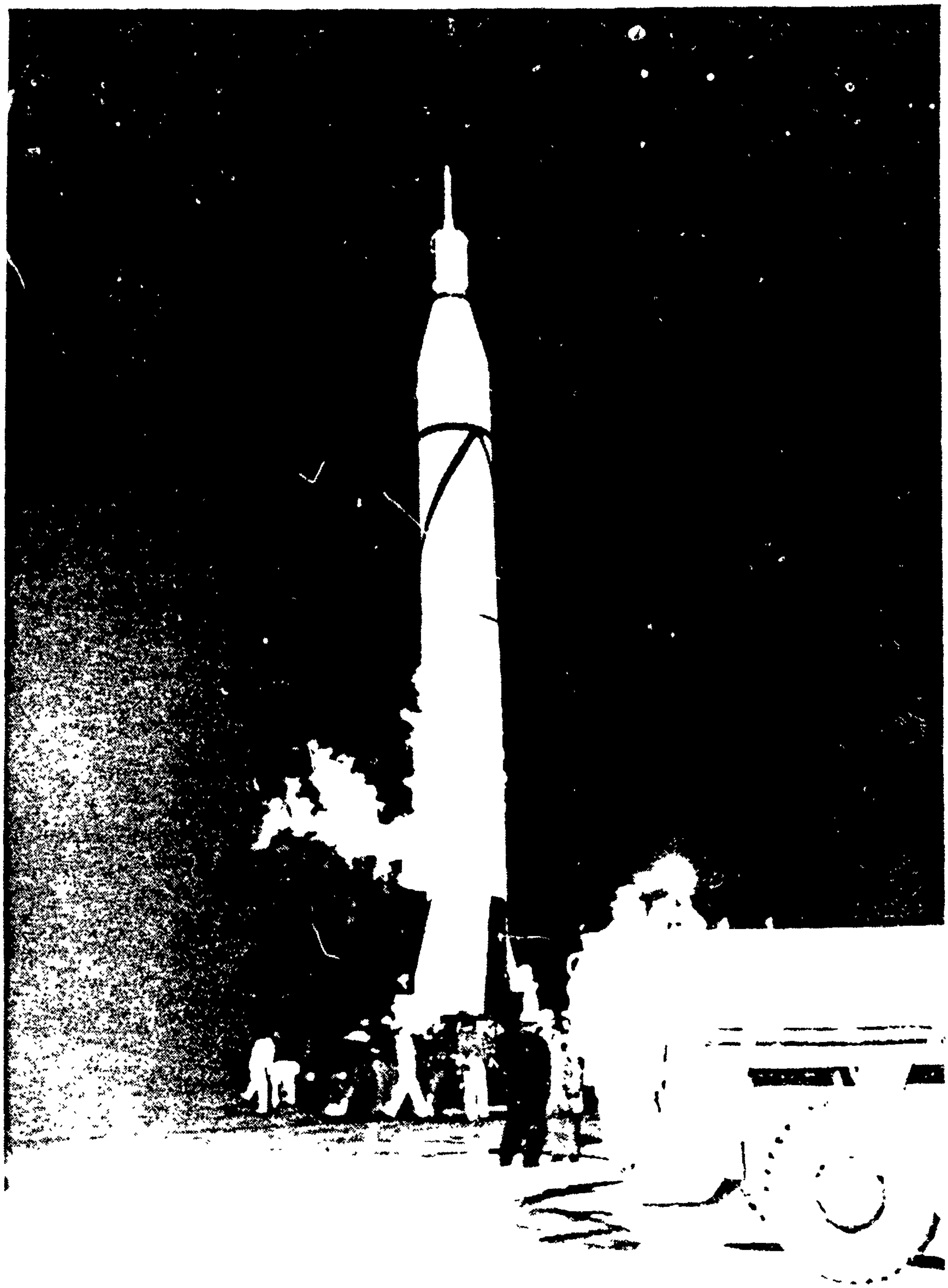


Plate 4—The U.S. Army's famous Jupiter C rocket is readied for its historic launch of the Explorer I satellite

Plate 5—A jubilant Dr. Wernher von Braun; Dr. James Pickering, Director of JPL; and Dr. James Van Allen, designer of the Explorer I radiation experiments, hold a model of the successful Jupiter C Redstone for reporters to photograph.

Plate 6—Secretary of the Army Wilbur Brucker inspects recovered Jupiter missile nose cones at the ABMA laboratory in February 1958.

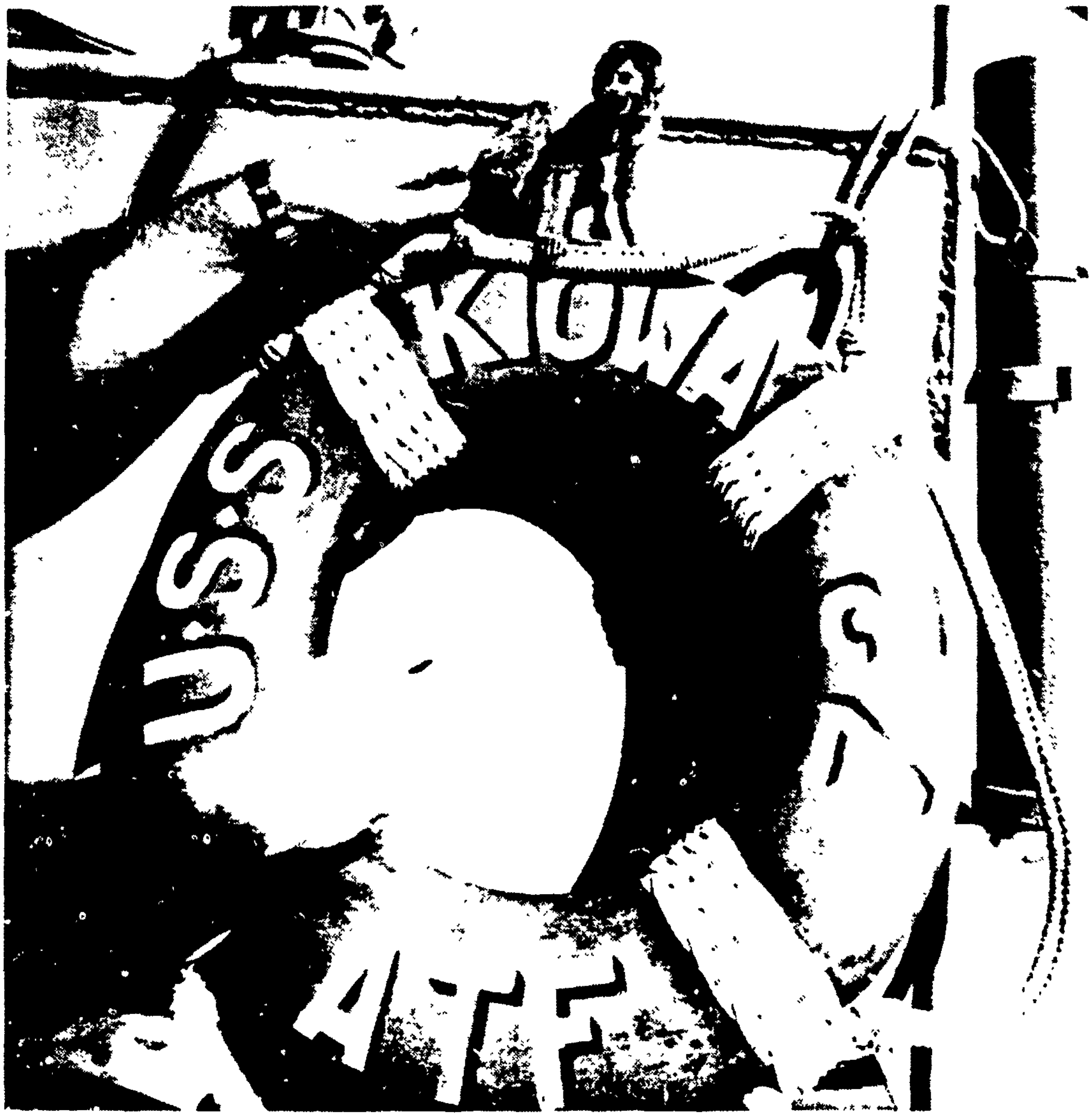


Plate 7—Miss Baker, one of the first animals to fly in space and return safely, is shown alive and well aboard the recovery ship USS Kiowa following her May 1958 flight aboard a Jupiter missile nose cone.

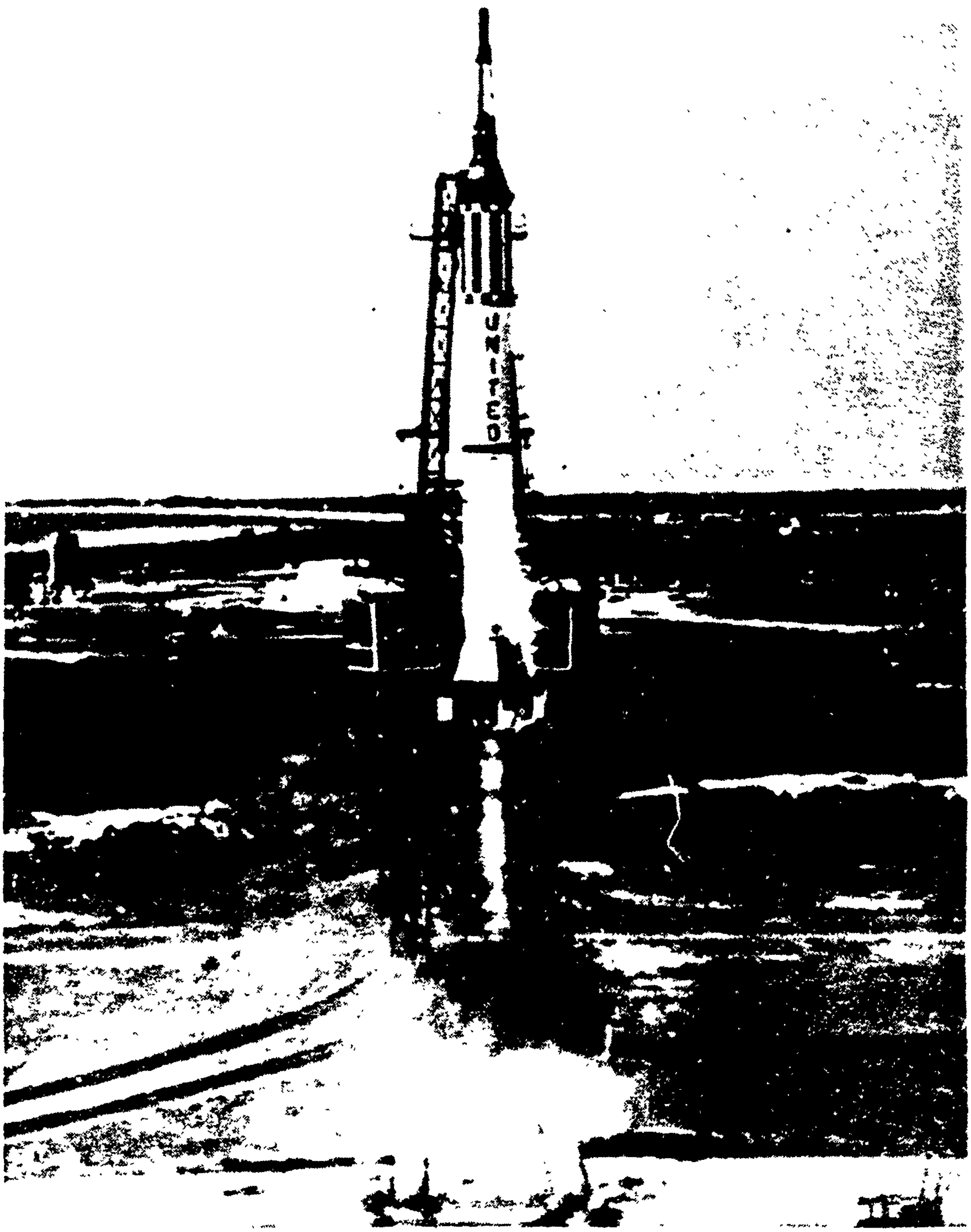


Plate 8—The first U.S. astronaut in space, Alan Shepard, blasts off in his Mercury capsule atop an Army Redstone in 1962, marking the beginning of U.S. manned spaceflight.

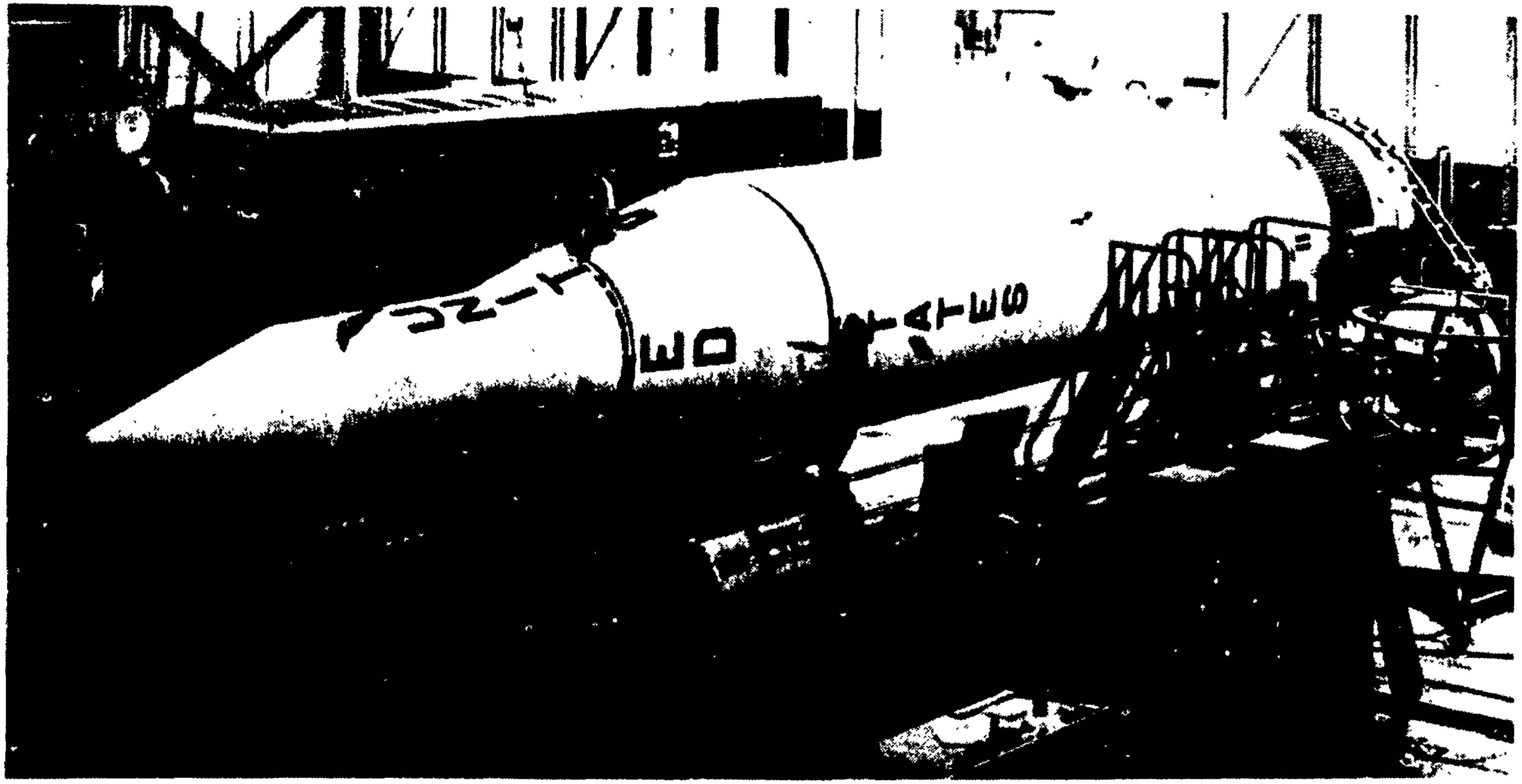


Plate 9—A Juno II missile undergoes a final checkout in the ABMA missile firing laboratory hangar at Cape Canaveral in 1959.

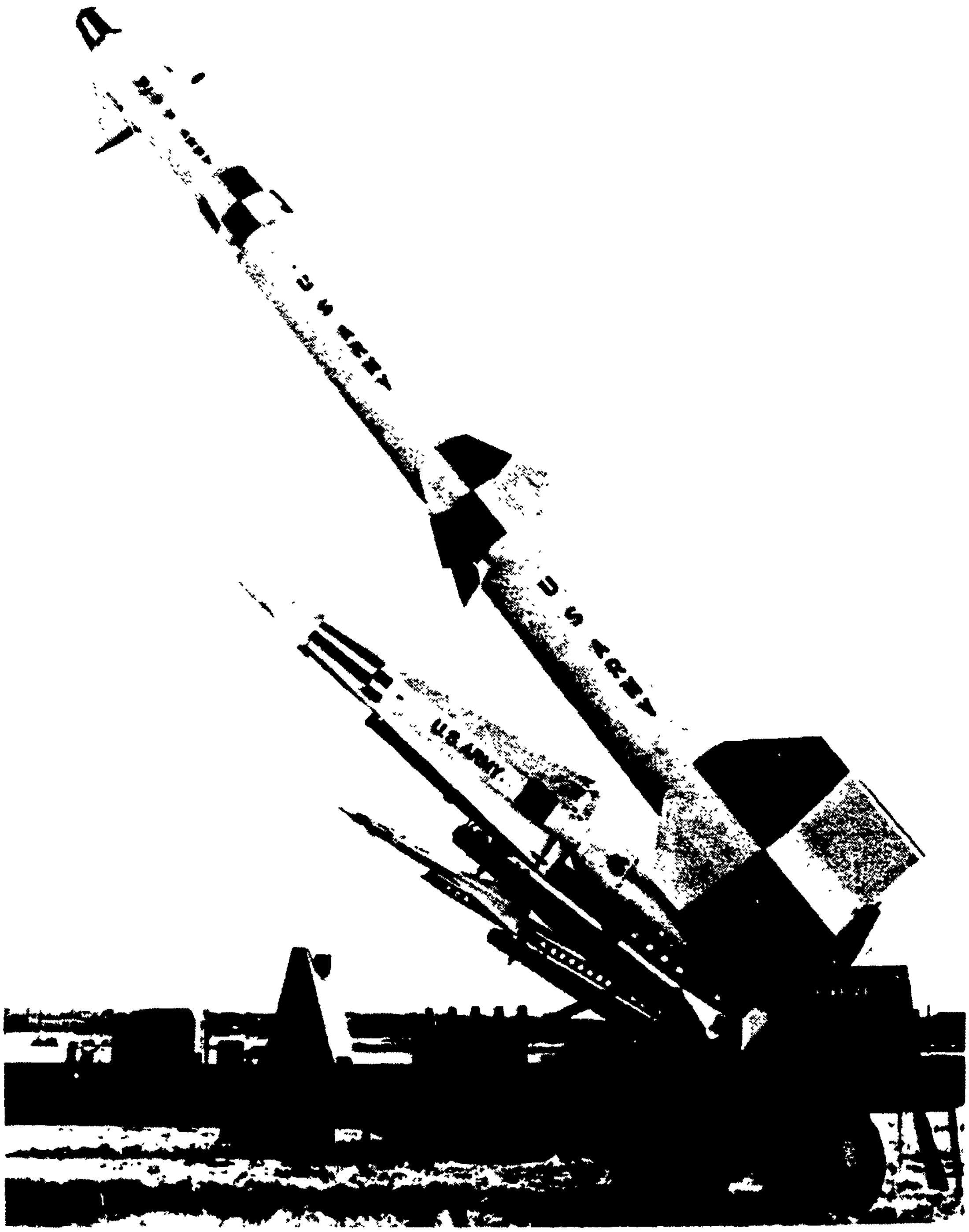


Plate 10—Static mockups show the technological evolution from the Nike Ajax to the Nike Hercules, to the Nike Zeus in the foreground.

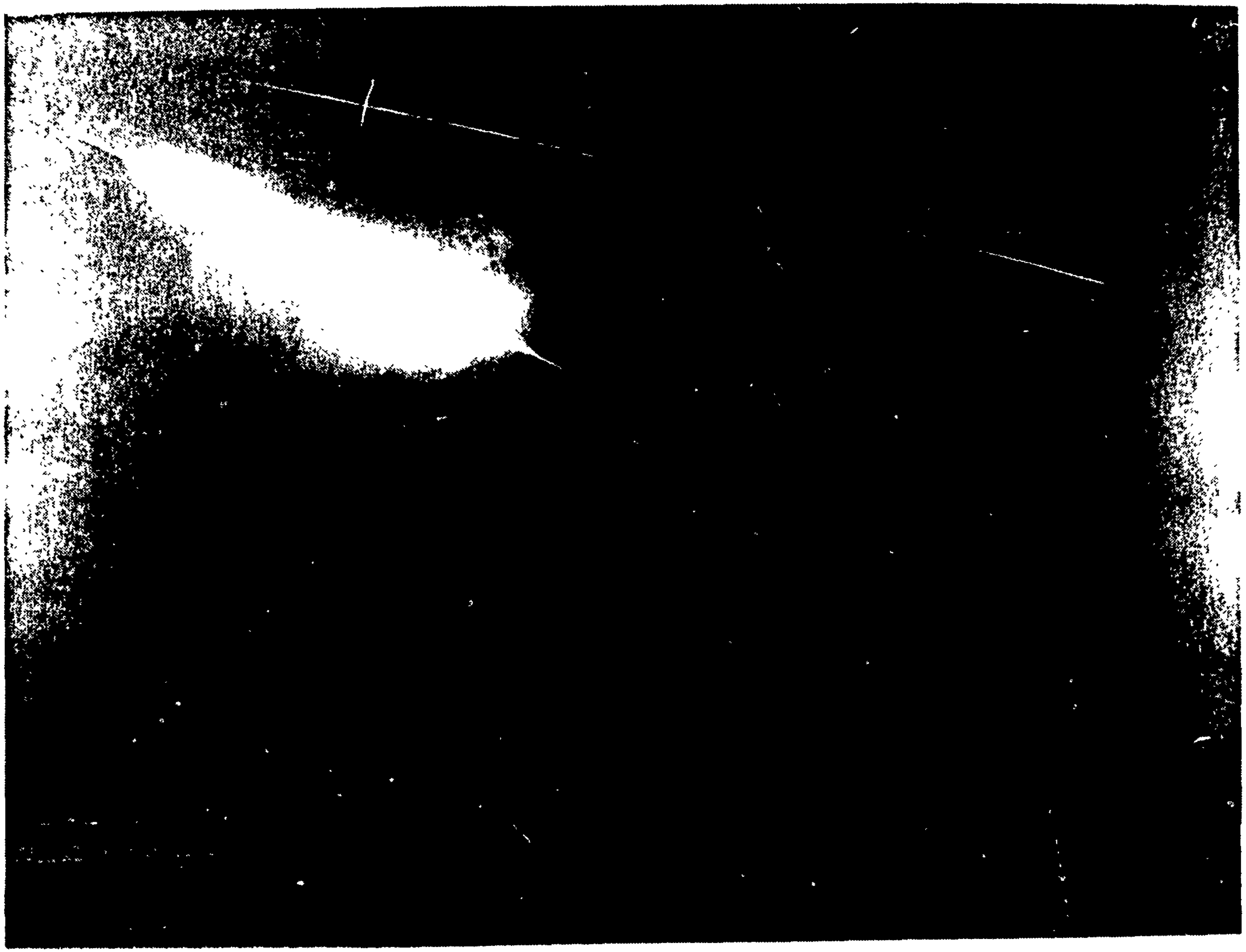


Plate 11—Film recorded the first successful intercept of an ICBM in the night sky above the Kwajalein Test Facility.

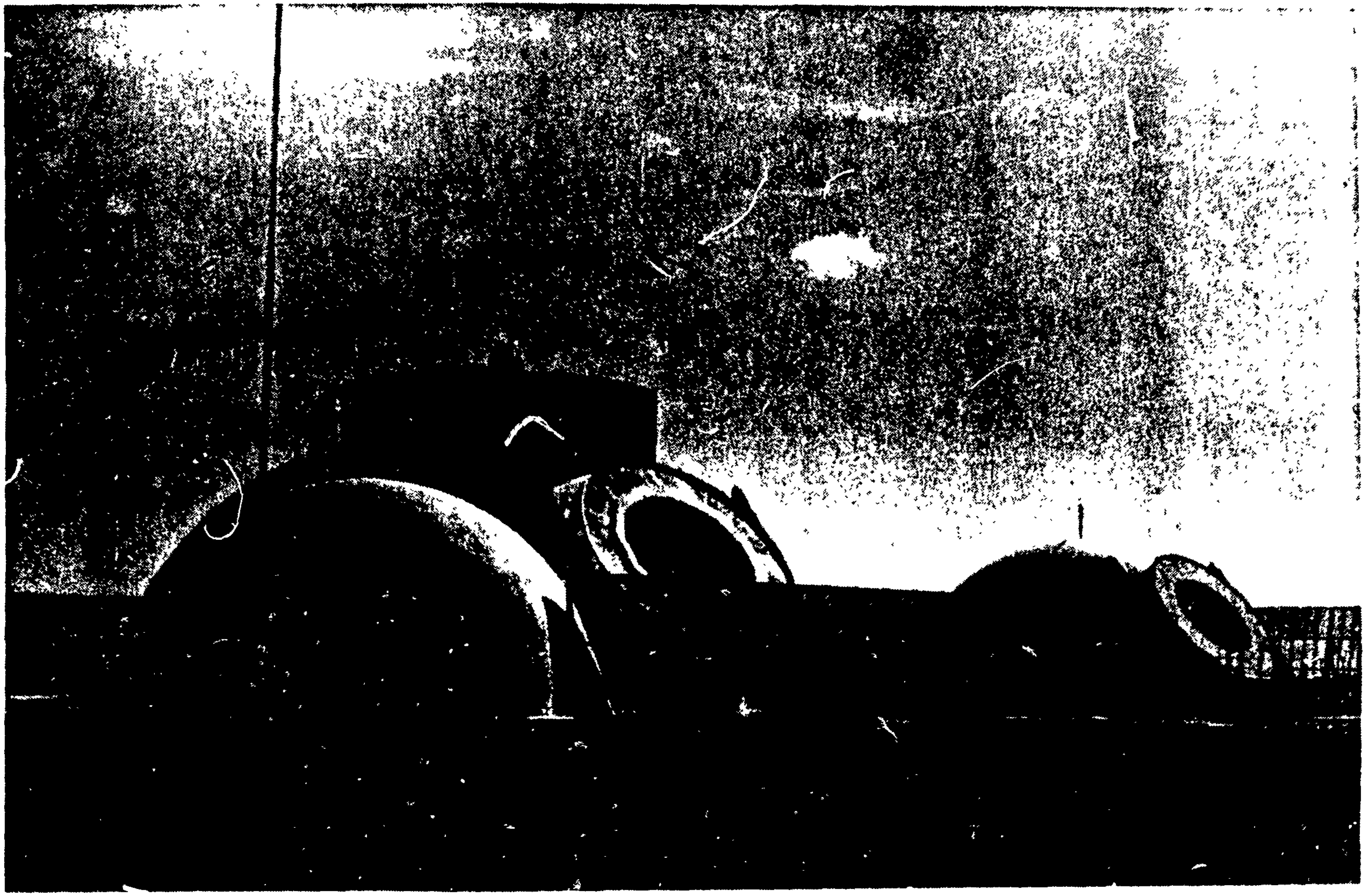


Plate 12—A Multifunction Array Radar built at White Sands Missile Range pioneered electronically steered, phased array technology that allowed more than one target to be tracked at a time.

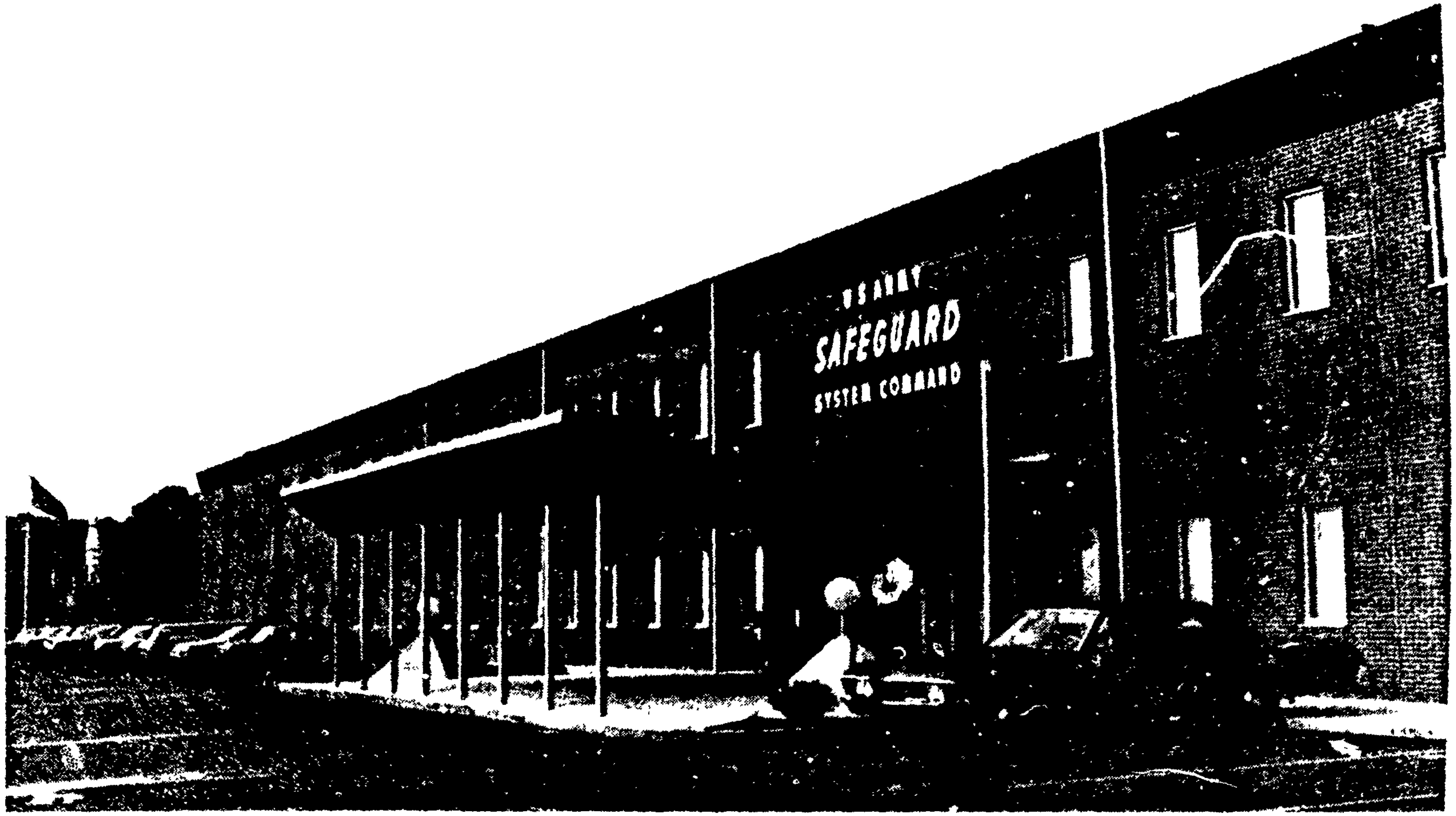
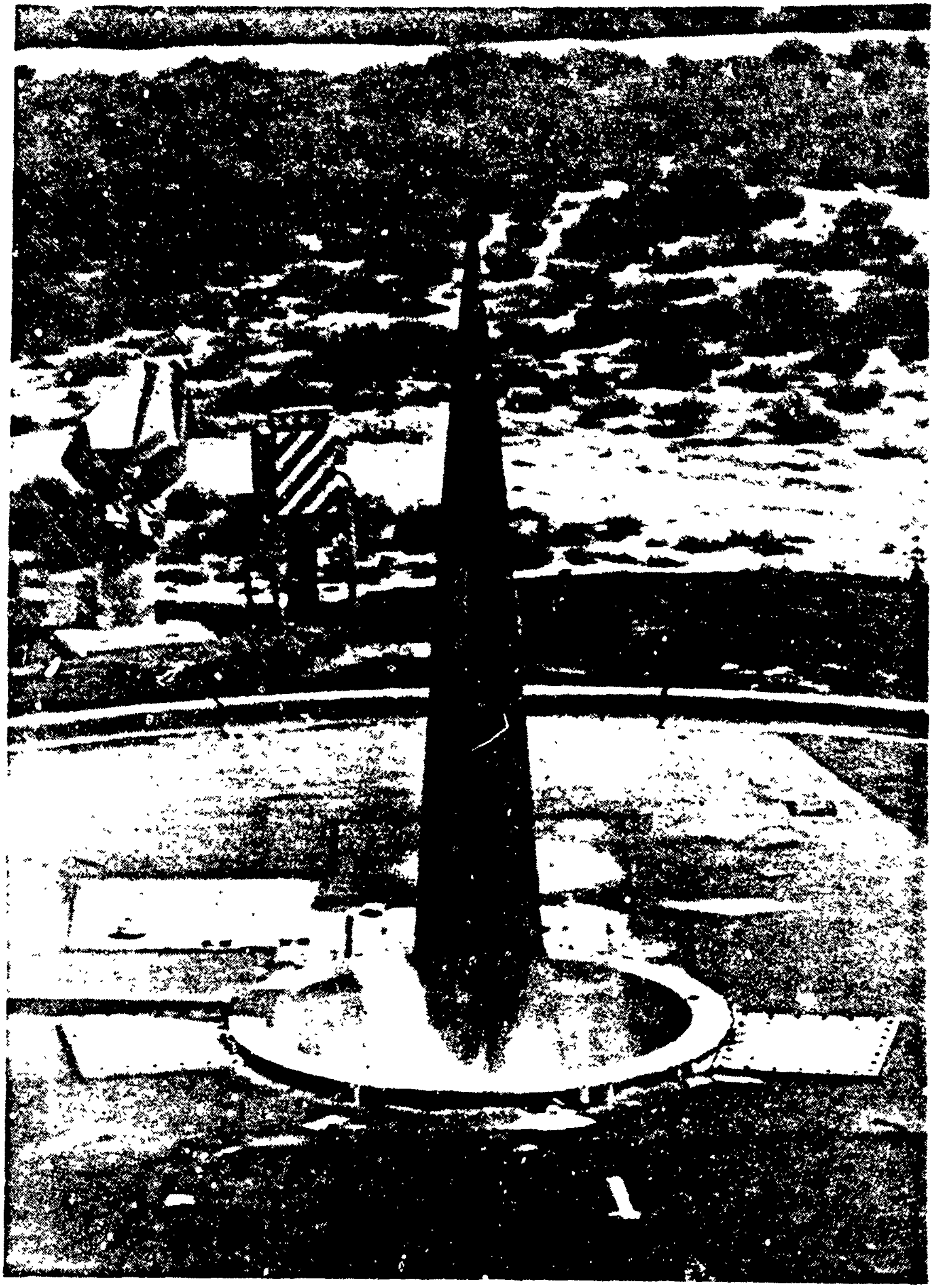


Plate 13-- The U S Army Safeguard System Command Headquarters was located in Huntsville, Alabama



Pla*e 14—The high-acceleration Sprint missile blasts out of its White Sands Missile Range launch cell during flight testing.

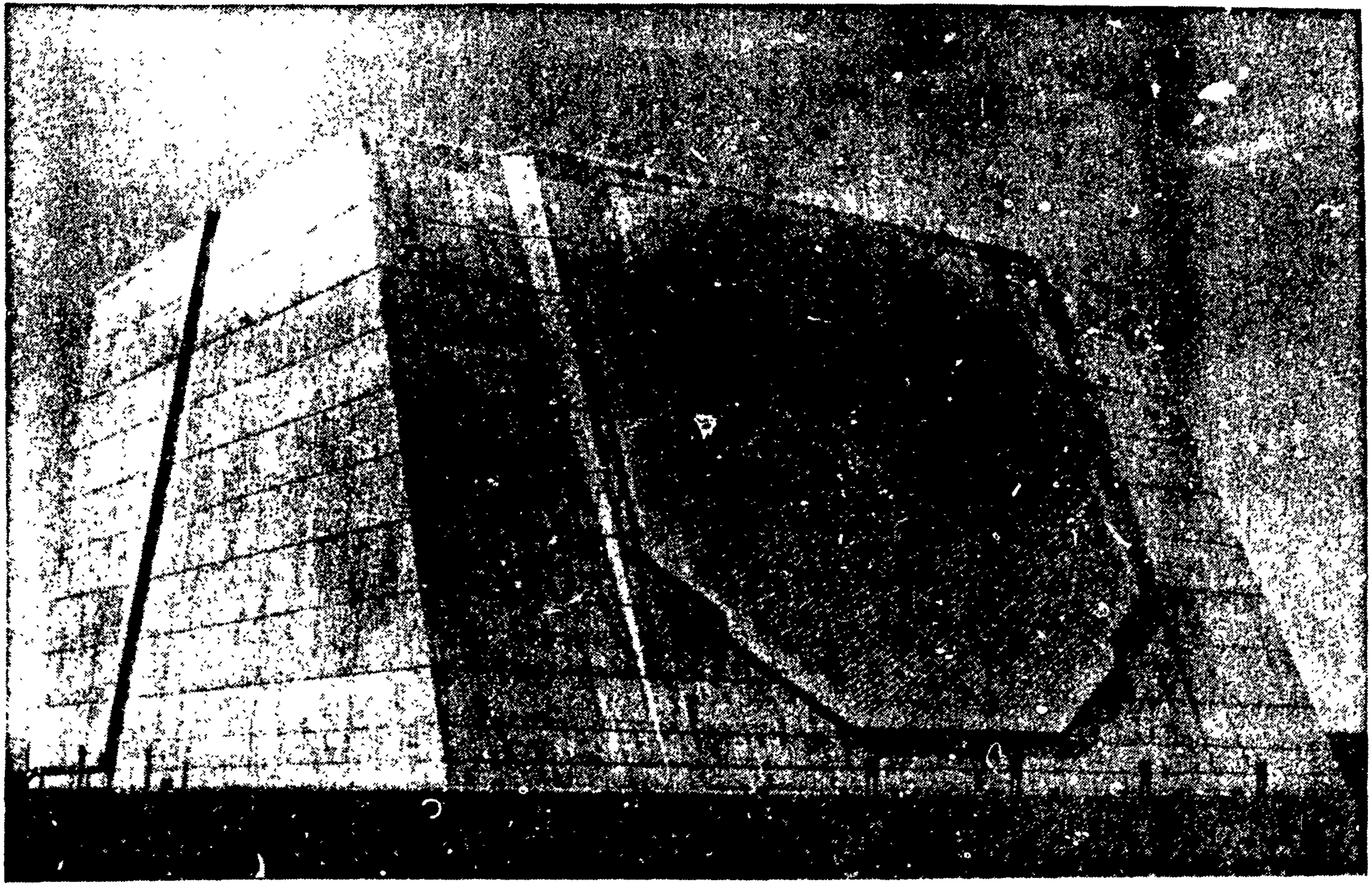


Plate 15—The Perimeter Acquisition Radar (PAR) for long-range target detection and tracking is shown at the U S. Army Safeguard PAR site in 1975.

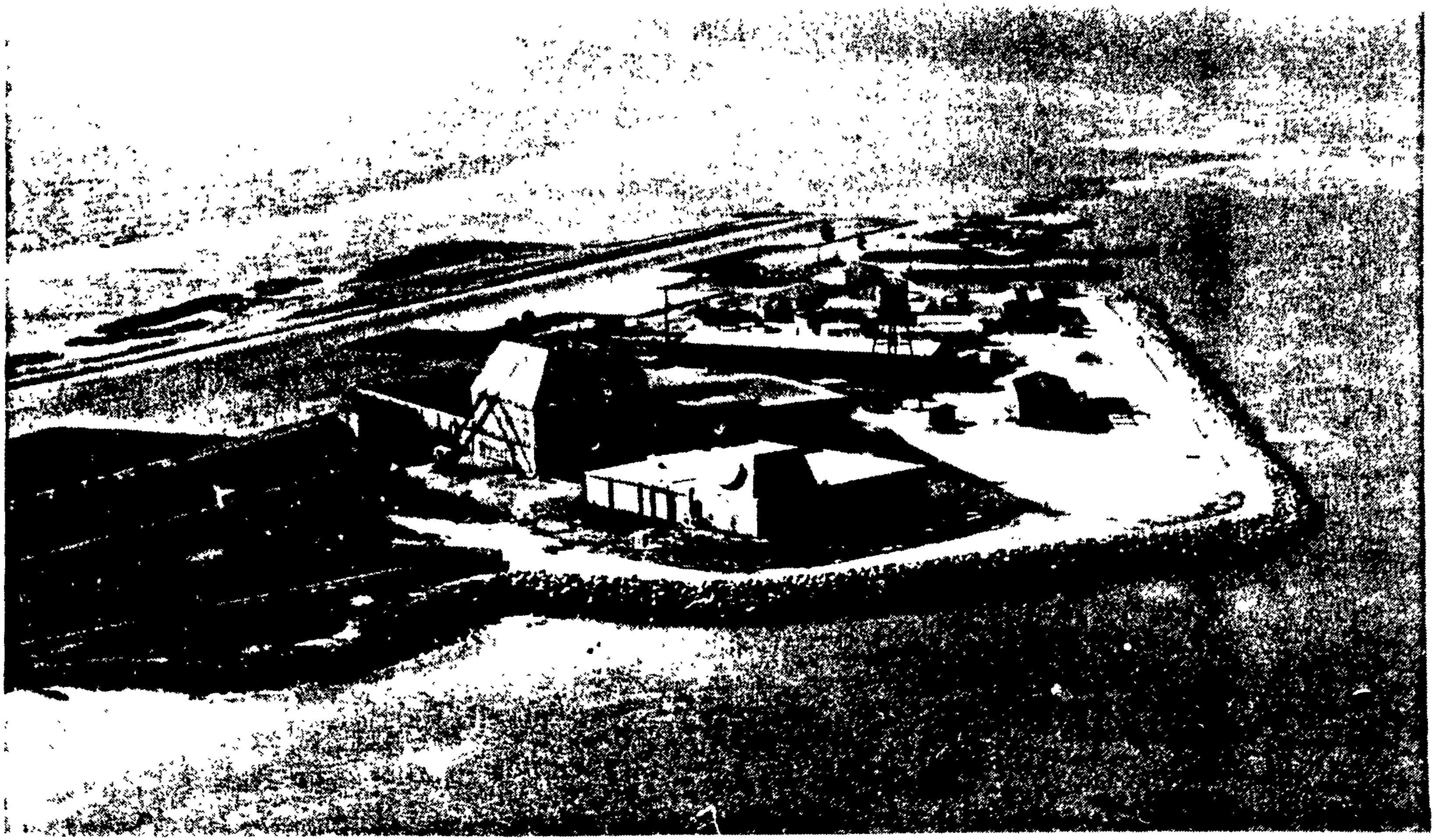


Plate 16—Progress in radar technology is evident in the contrast b. ·veen the Safeguard era Missile Site Radar and the smaller follow-on Site Defense Radar test facility built at Meck Island in the Central Pacific.

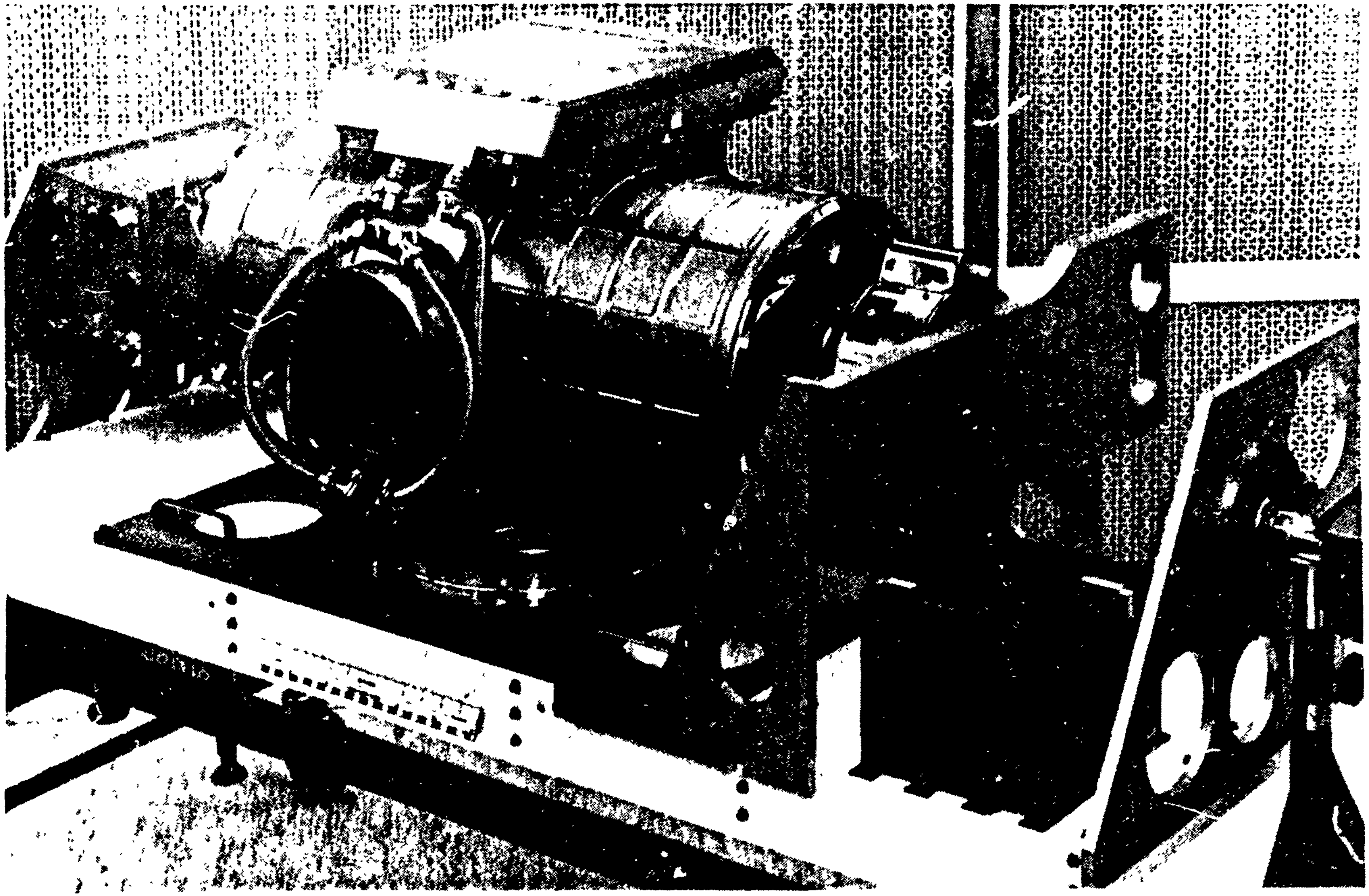


Plate 17—A BMD Advanced Technology Center infrared optical sensor is shown prior to mounting into a specially designed payload vehicle as part of the Designating Optical Tracker (DOT) experiment.

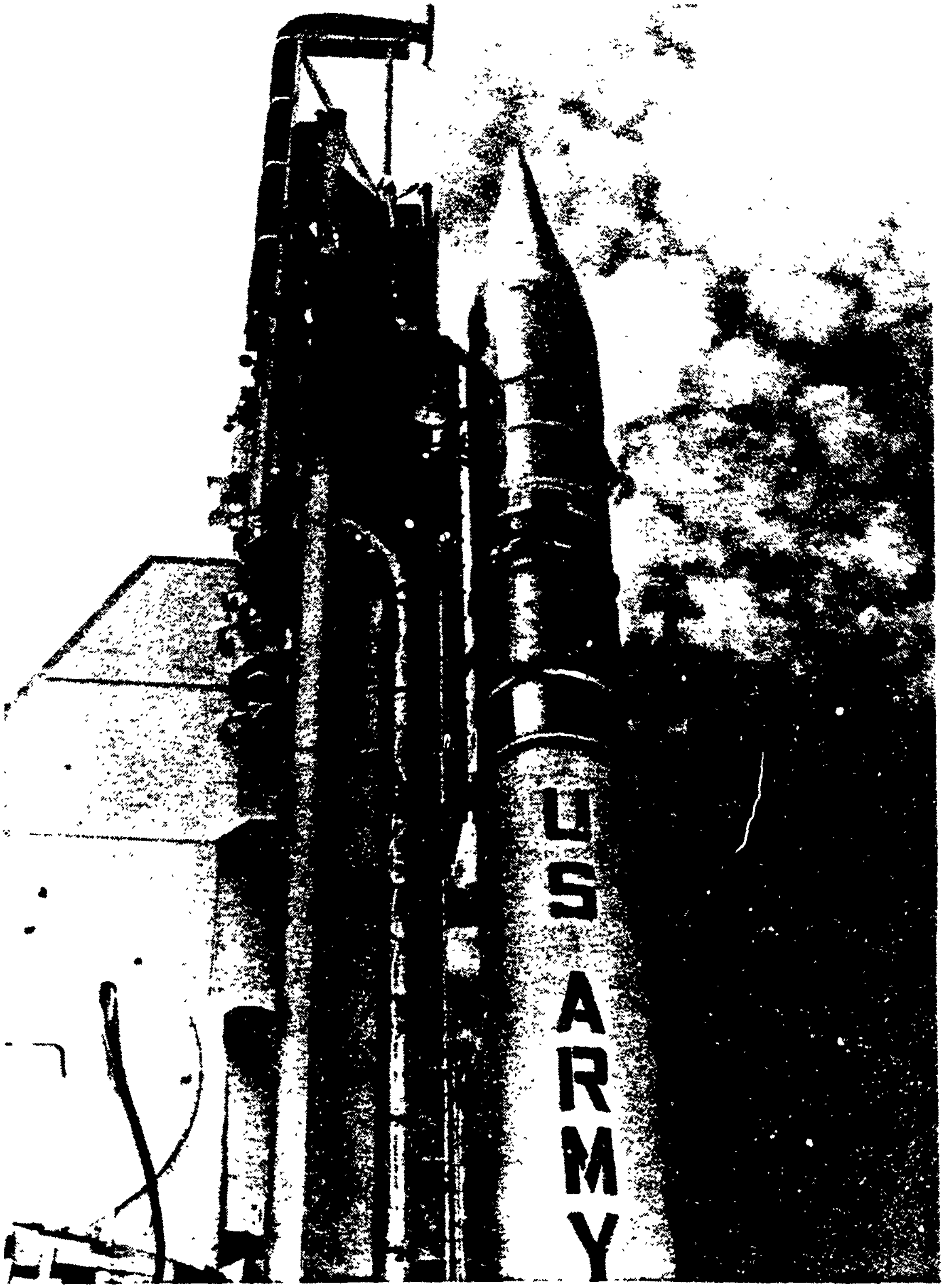


Plate 18—The DOT payload package is mounted on a Castor I rocket prior to launch at Kwajalein Missile Range.

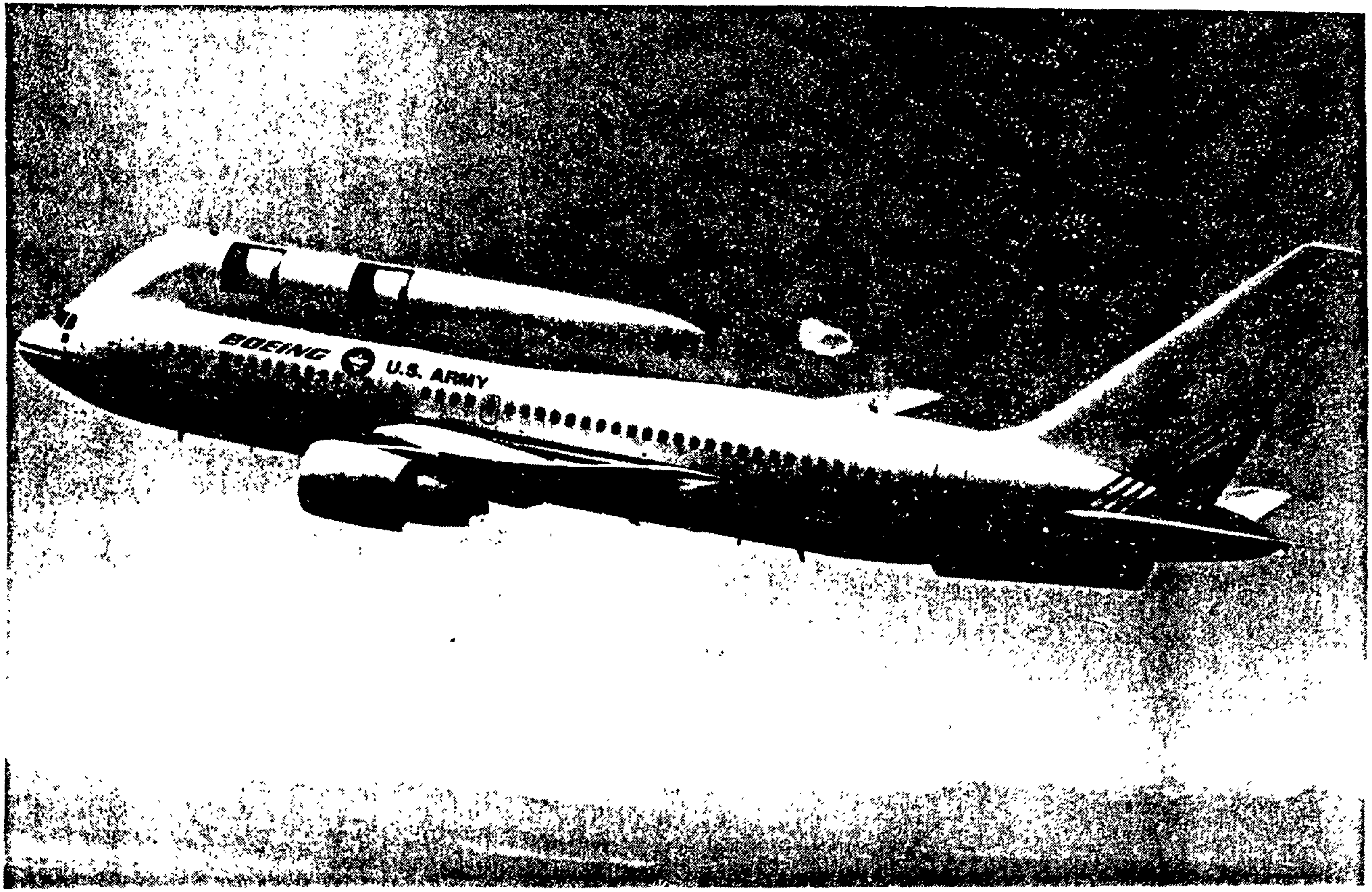


Plate 19—A modified Boeing 767 successfully conducted flight worthiness tests in 1987 in preparation for later mounting of the Airborne Optical Adjunct sensor.

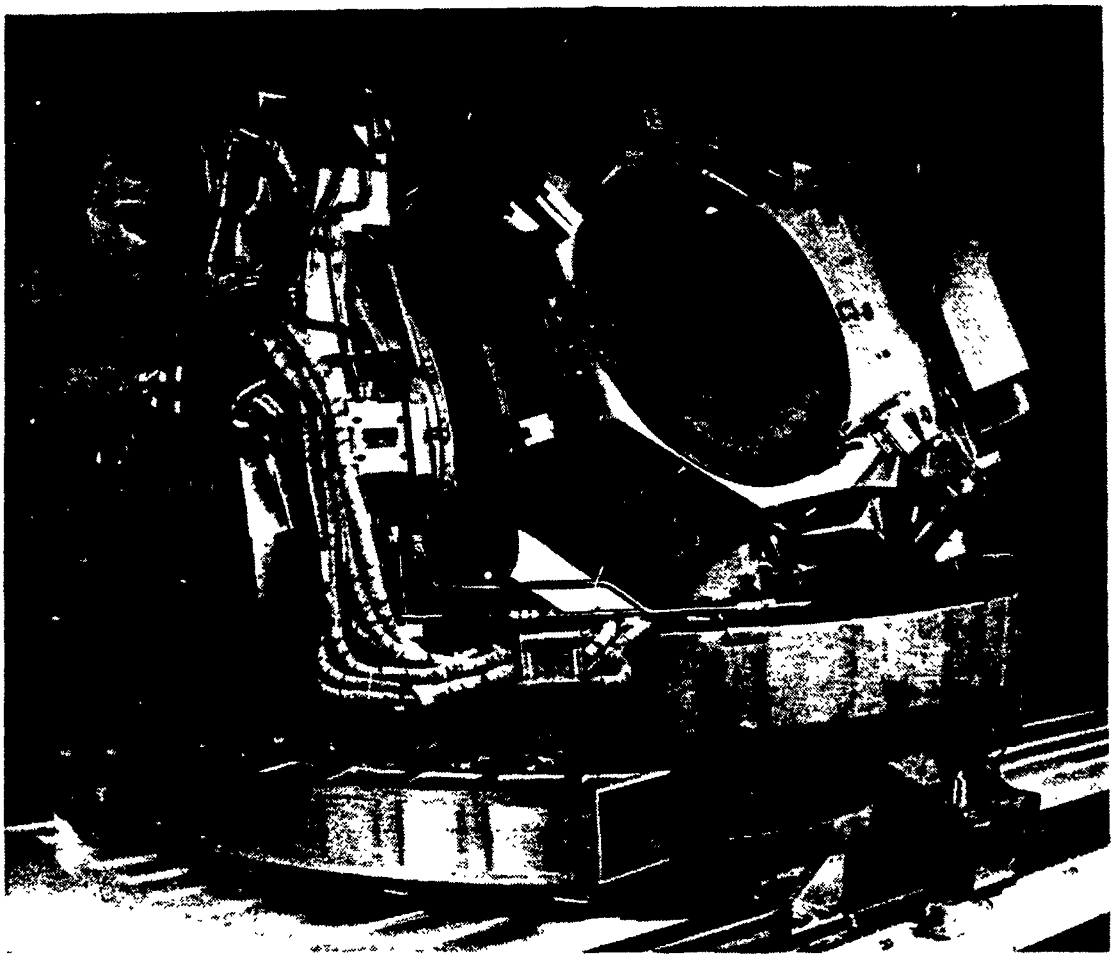


Plate 20—The one-of-a-kind USASDC Airborne Optical Adjunct sensor is shown undergoing inspection prior to flight experiments to determine the utility of long-wave infrared sensors to detect and track enemy ballistic missile warheads.

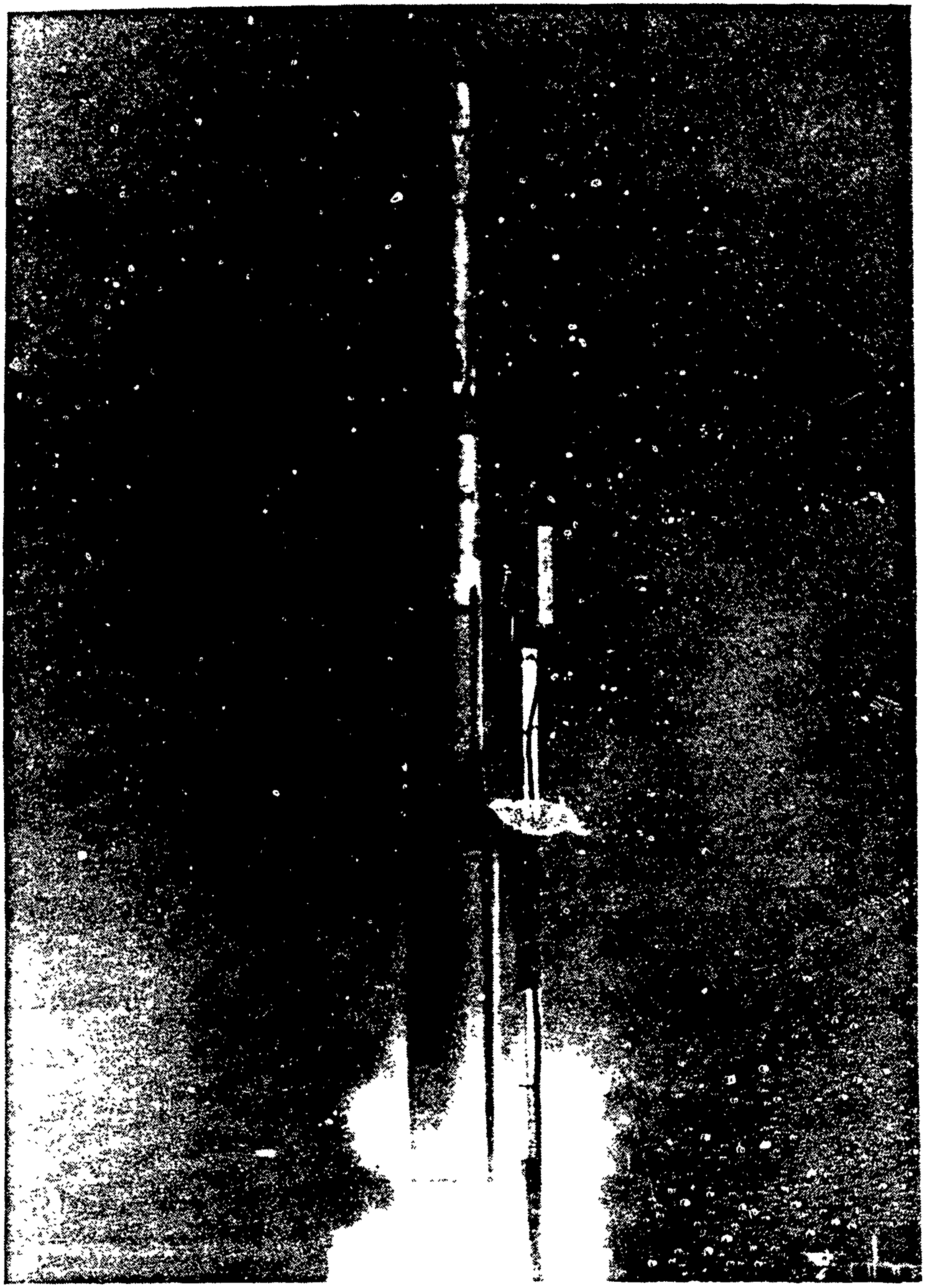


Plate 21—In June 1984, the U S Army launched the Homing Overlay Experiment (HOE) from Kwajalein Atoll to make an exoatmospheric intercept of an incoming warhead

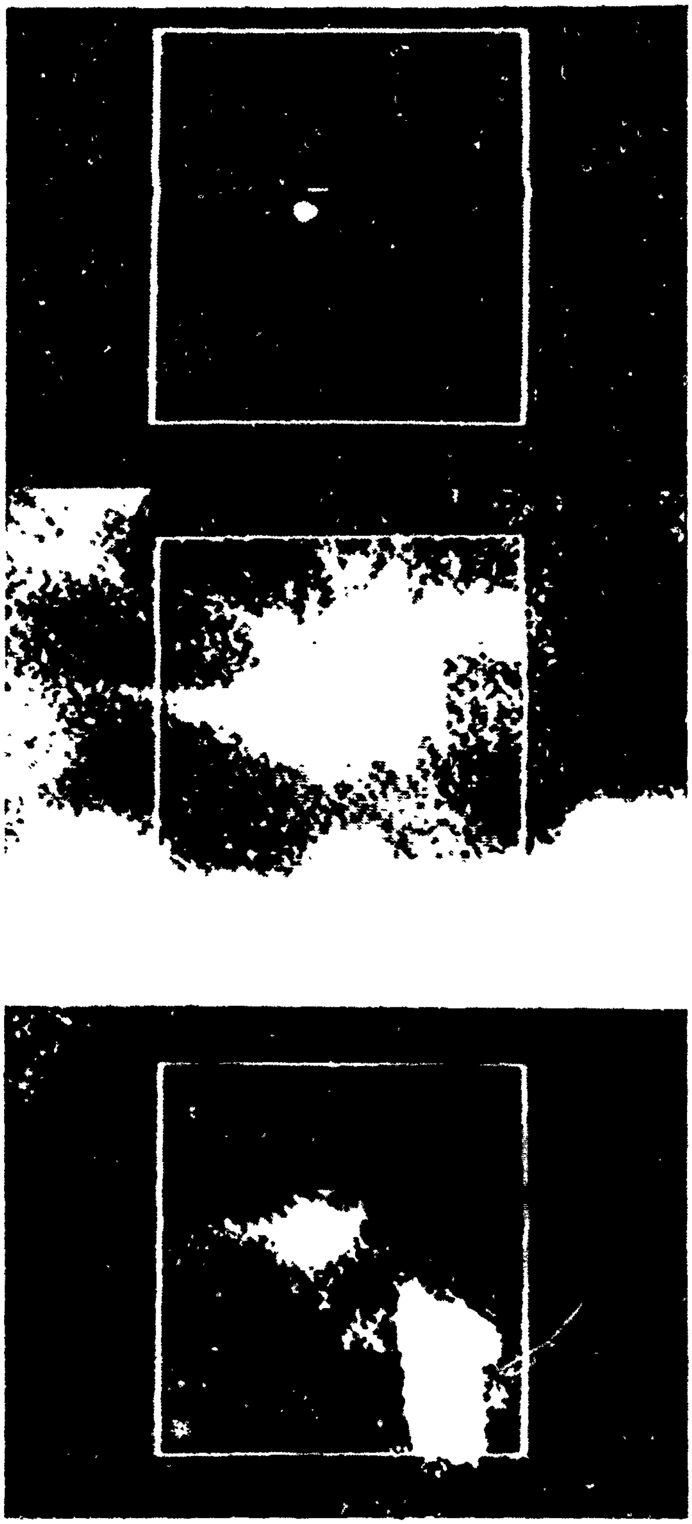


Plate 22—Aerial photography shows the U.S. Army's HOE making the first successful nonnuclear intercept of an ICBM warhead in space.

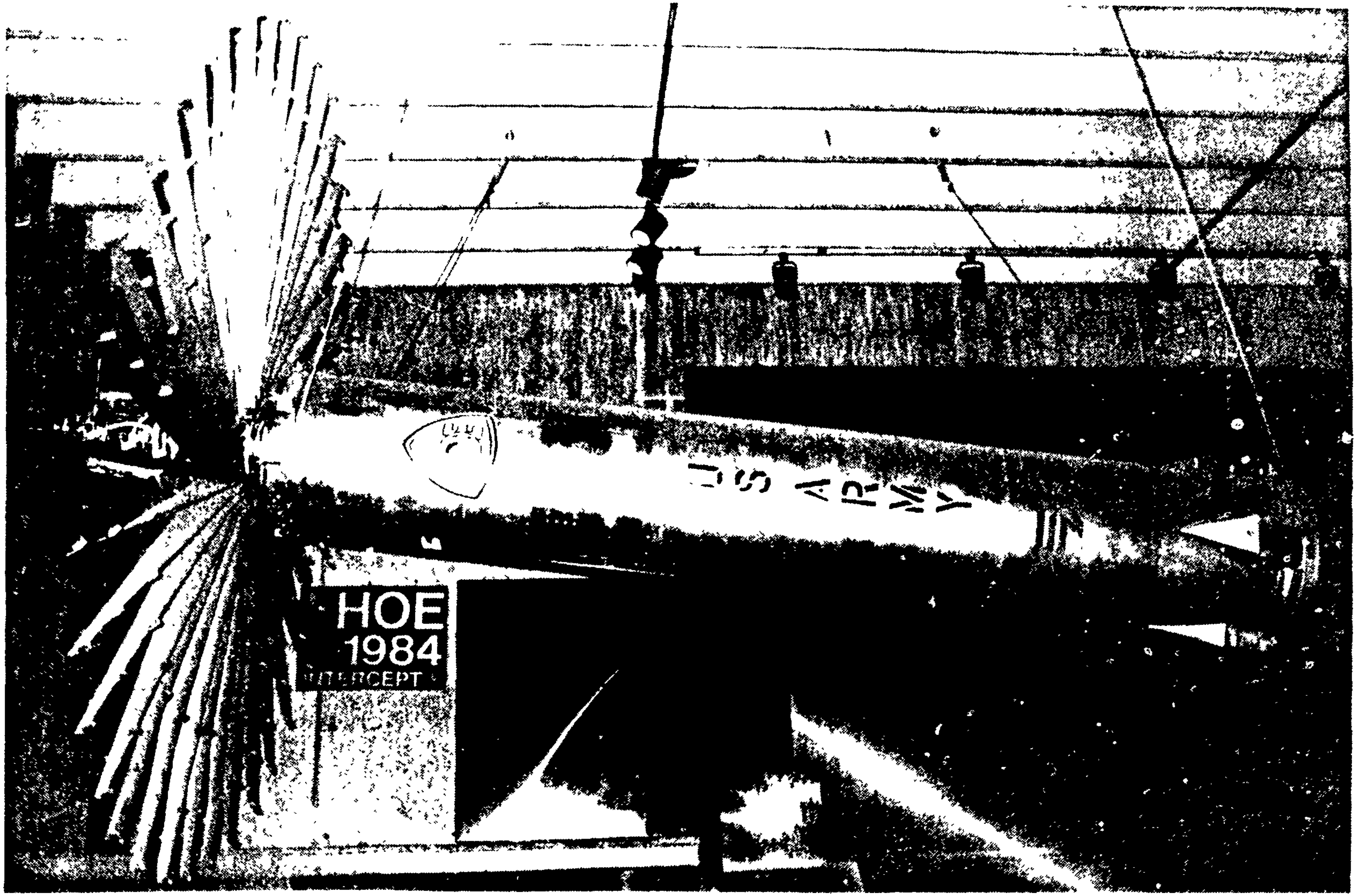


Plate 23—An actual HOE vehicle with its radial net unfurled like the ribs of an umbrella hangs in the Alabama Space and Rocket Center in Huntsville, Alabama

Plate 24—In 1987, the Army FLAGE successfully intercepted a tactical Lance missile at White Sands Missile Range.

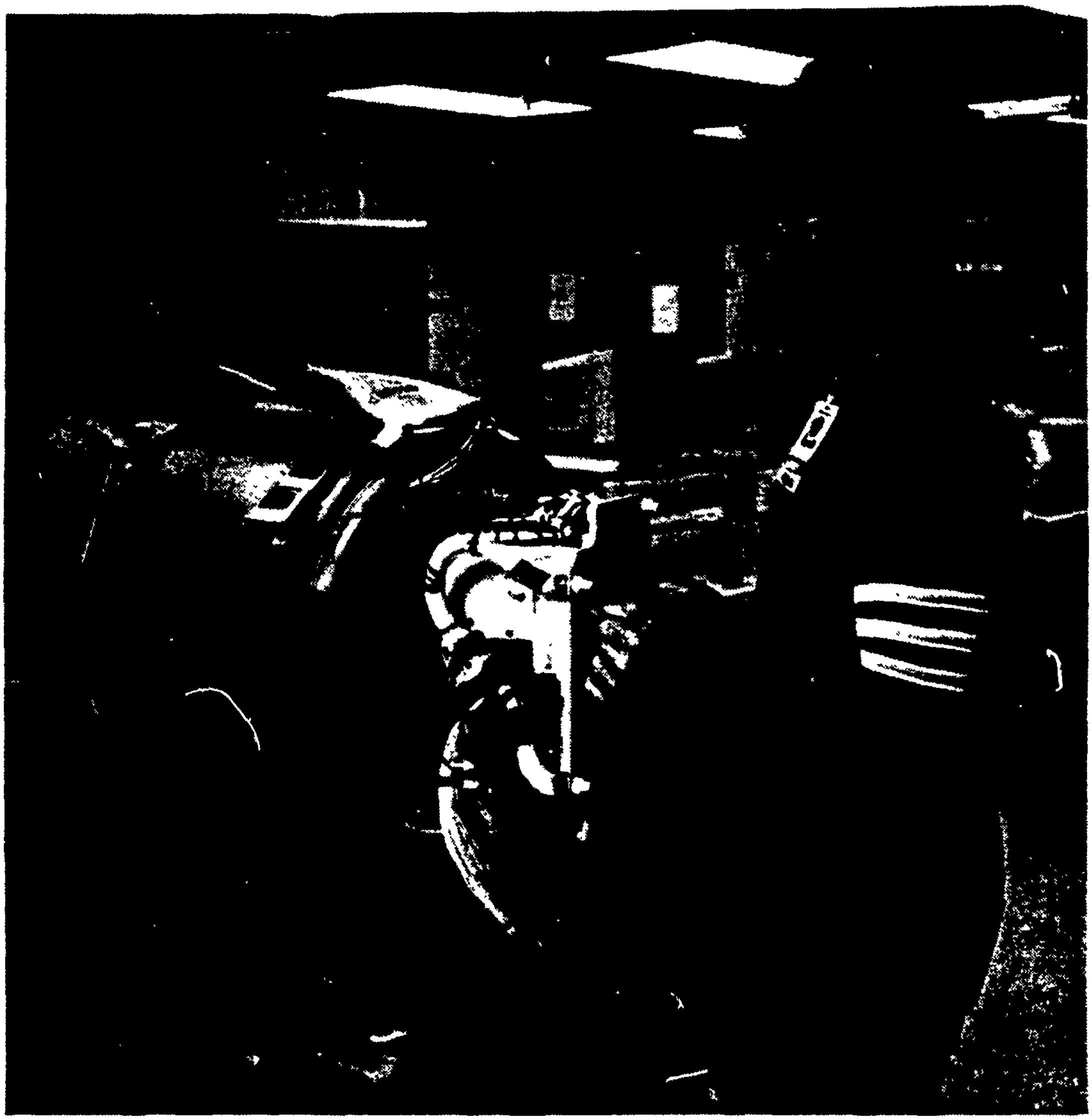


Plate 25—Hughes employee Mike Ashley inspects control "brain" section of the HEDI kill vehicle.

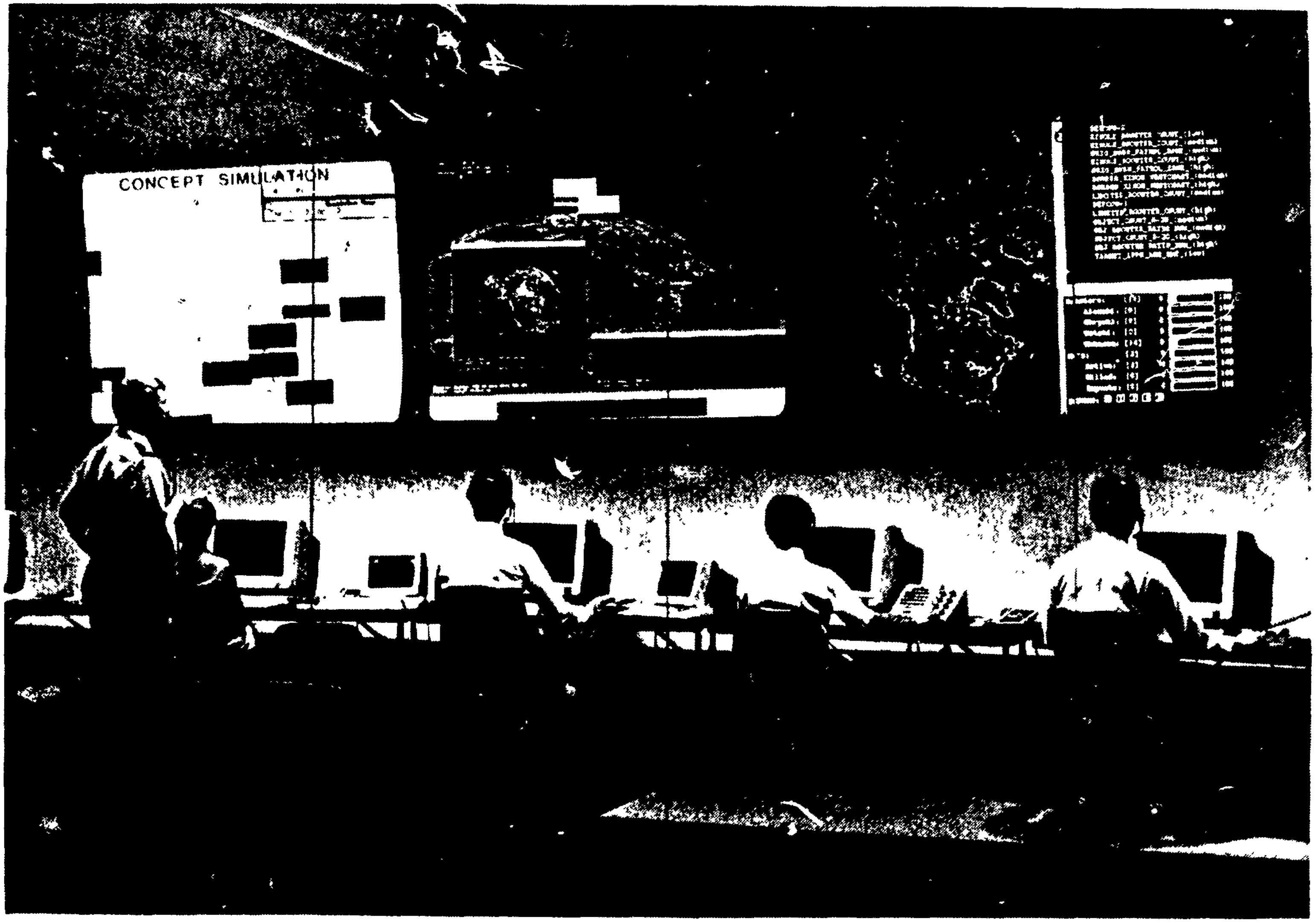


Plate 26—LTC James Pepper conducts a BM/C3 research simulation in the USASDC Advanced Research Center war room.

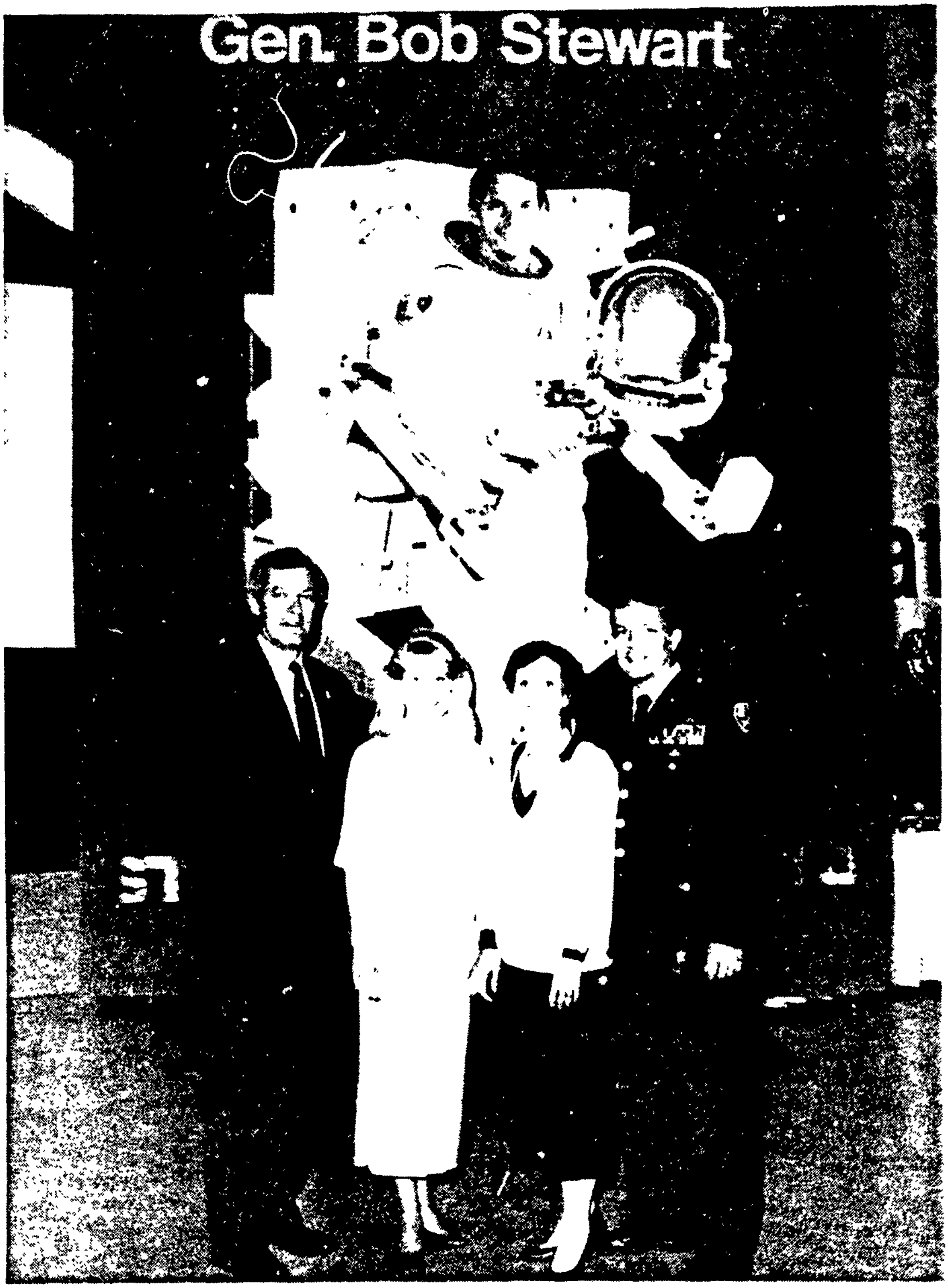


Plate 27—The Army's first astronaut, Brig Gen Robert L Stewart, USASDC deputy commander, poses with his wife Mary and daughter Jenny, and Ed Buckbee, director of the Alabama Space and Rocket Center

III. PERIGEE PHASE, 1961–1976

The U.S. Army did not "lose" its lead in space exploitation after 1961. In fact, it responded to the nation's needs by applying available space technology:

- To enhance theater operations by becoming a significant user and operator of long-haul satellite and ground station communication networks.
- To control space by steadily and significantly developing and deploying ABM and ASAT systems.
- To deliver force by deploying several nuclear-armed tactical rockets and ballistic missiles.

However, several constraining influences arose during the period 1961 through 1976 which had sufficient combined influence to stop the Army from conducting publicly impressive space booster and satellite launches, from performing reconnaissance satellite work, from operating air and space defense units, and from separately operating long-haul communication networks. The constraining influences were: the formation of NASA, increased centralized DoD management of space systems and issuance of government space mission and roles directives, tri/joint service development and operation of long-haul communication systems, the Army's involvement in the Vietnam war (with its need to develop tactical missiles), and international treaties limiting ABM defense efforts.

1958–1976 NATIONAL POLICY AND THREAT

The formation of NASA, between October 1958 and 1 July 1960, incorporating major elements of the Army's missile and space R&D effort, was a proud moment for the service. But this reorganization of America's space activities was also the first constraining influence on the Army's exploitation of space role during the 1960s and 1970s. Major missile R&D facilities (worth hundreds of millions of dollars), thousands of highly skilled Army civilian personnel, funding, launch vehicle programs, and satellite projects were rapidly shifted out of the Army. This shift removed from the ground service an influential constituency and expertise base for continued Army satellite and long-range booster participation.

In January 1961, the Wiesner committee report was published; it declared that NASA, DoD, and the three services' space programs were poorly coordinated. In

response to the need for better space R&D management, DoD issued Directive 5160.32 in March 1961 establishing satellite development missions and roles. This was the second constraining influence on Army space activities. The DoD directive allowed each service to conduct preliminary satellite technology research, but the USAF would perform advanced development, launches, and operate all DoD reconnaissance satellites except CIA/NSA reconnaissance satellites. The Army was allowed to continue its ADVENT communication satellite work. But the Army had been restricted from controlling the acquisition of service supporting launch vehicles and reconnaissance sensor satellites.[1]

While the United States was organizing itself to get into space and effectively operate in orbit, it faced an expanding global communist threat. The Soviet Union continued developing its ICBM nuclear delivery force stationed deep within its borders. And it threatened the continental United States during the Cuban Missile Crisis by positioning IRBMs in Cuba during October 1962. Then from 1966 through 1968, the USSR tested a co-orbital ASAT system. Soviet ASAT efforts disappeared until 1975 when several U.S. satellites were mysteriously blinded by a light source located in the USSR. The following year the Russians resumed co-orbital ASAT testing. Simultaneously, the Soviets deployed a formidable armor, mechanized infantry, and artillery force along the Iron Curtain in Europe. Meanwhile, the Eisenhower and later the Johnson administrations determined that they must confront the North Vietnamese communist forces in Southeast Asia.[2]

The Army's response to the Southeast Asian threat was the third influence reducing its exploitation of space. The Regular Army went to war in Vietnam beginning in 1961. By 1965, U.S. Army Vietnam (USARV) was established and the multi-service, military in-country strength grew to 180,000; by 1967, it rose to 500,000. During the war, two thirds of all fighting forces operating in the theater were Army. By January 1969, U.S. Army in-country personnel strength peaked at 365,000.[3]

In support of this warfighting effort, the Army's induction and basic training system focused on sending forces to fight in Southeast Asia. Officer and NCO schools emphasized Southeast Asia warfare. The Army's logistic tail was dedicated to continually and rapidly moving supplies across the Pacific in support of 1.3 million men.

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[1]LTC J. W. Holdsworth, *The Army Role in Space*, U.S. Army War College, Carlisle Barracks, PA, 5 June 1984, p. 18; Stares, pp. 60–61.

[2]Stares, pp. 135–137, 213, 262; Kwajalein, p. 55.

[3]E. C. Jolliff, *History of the U.S. Army Missile Command, 1962–1977*, MICOM Historical Division, Monograph DARCOM-84M, 29 July 1979, pp. 115–116; Matloff, pp. 619–627 and 633.

The individual American soldier in Vietnam received about 96 pounds of supply support per day, more than twice the amount per man in the Pacific theaters of WWII.[4] The Joint Chiefs of Staff (JCS) and senior Army service leaders devoted themselves to winning the Southeast Asia war while holding the front in NATO and Korea.

The U.S. theater structure, commanded by an Army general, grew to two Army corps headquarters, seven divisions, two separate infantry brigades, one airborne brigade, and one air cavalry regiment. The vast majority of officers and senior NCOs who manned this force were regular army professionals, many of whom served multiple tours in Vietnam. Assignments to NATO, Korea, and the continental United States (CONUS) were temporary respites before returning to the war. Regular Army soldier losses were severe among the 30,200 soldiers killed in combat, among the approximately 6600 who died from other causes, and among the 100,000 wounded requiring hospital care.[5]

The magnitude and effects of this theater war caught the Regular Army's attention. The war became the Army's major focus while the fighting continued through 1972 and during the post-war questioning and recuperation period through 1976. Surviving and winning in Vietnam was a far more immediate and urgent priority than defining requirements for future space systems and future wars. The theater ground war was fought with little direct tactical aid from space assets, except for the use of long-haul satellite communications. Involvement in the Vietnam War was a primary inducement for the Army to focus on non-space activities during the period 1963 through 1976.

The natural service drive to field effective, near-term, tactical weapons for use in Europe and Southeast Asia was the fourth influence restricting development of pioneering space exploitation capabilities. Battlefield missiles appeared to offer front-line Army units facing Warsaw Pact armored forces more operational combat power than did space systems. During the 1960s and 1970s, the near-term, potential utility in Vietnam of aerial missile artillery, wire-guided anti-tank missiles, and low-altitude air defense missiles was far more believable than the claimed benefits of costly space-based systems. Therefore, spin-off technology (launch guidance, propellant, sensor, and command and control [C2]) from the Army space/ABM research was used to develop small, accurate battlefield tactical missiles. Significant research time, effort, and funds were devoted to developing, acquiring and fielding missiles, such as the 2.75-inch folding fin aircraft rocket (FFAR), the Tube-launched Optically guided Weapon (TOW), HAWK,

[4]Matloff, p. 629.
[5]Matloff, pp. 633–646.

and Redeye. In fact, whole new families of surface-to-surface and surface-to-air missiles emerged with both short- and long-range capabilities.[6] Figure 4 depicts this Army space and battlefield missile arena.

This battlefield missile research effectively competed for the Army's high-technology attention and money. For example, USARV requested and received emergency production and deployment of the 2.5-inch aerial rocket in 1962, the Light Anti-tank Weapon (LAW) in 1968, and the TOW in 1972.[7] It is accurate to say that during the 1960s and 1970s the Army was far more concerned with exploiting tactical missile capabilities than with exploiting space capabilities.

During the perigee phase, communication satellites and long-haul communication ground stations were extensively exploited by the Army to achieve effective global military communications to crisis regions such as Vietnam. Because of the commonalty of satellite and ground station technology to meet the needs of each service, DoD-ensured R&D and field operation of long-haul communications systems was conducted in a tri-service or joint service manner. As a tri-service contributor, the Army was repeatedly assigned ground station/terminal design and operation responsibilities beginning as early as 1961.[8] This trend was the fifth constraining influence on Army space exploitation efforts.

While the Vietnam War was in progress, the United States signed four treaties with the Soviet Union agreeing to specific constraints on space and ABM system deployments. In 1963, Congress ratified the Limited Test Ban Treaty prohibiting nuclear explosions in outer space. This agreement was followed by the Outer Space Treaty of 1967 banning nuclear and other mass destruction weapons from earth orbit or upon celestial bodies. In 1972, the interim Strategic Arms Limitation Treaty (SALT) was accepted. Both superpowers agreed not to interfere with national technical means (NTM) of verifying compliance with strategic arms limitation agreements. The ABM Treaty was signed in 1972 and modified by protocol in 1974, and went into effect in 1976. The modified treaty limited each country to 100 ABM missiles for point defense of either the nation's

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[6]Matloff, p. 584; Jolliff, Chap. 7, pp. 115–145.

[7]Jolliff, Chap. 7, pp. 115–125.

[8]F. J. Rolack and G. Thompson, *History of the U.S. Army Communication Command (USACC)—Origin to 1976*, USACC Historical project USACC-3M, Ft. Huachuca, AZ, December 1979, pp. 147–148; *A History of the Signal Corps*, p. 17.

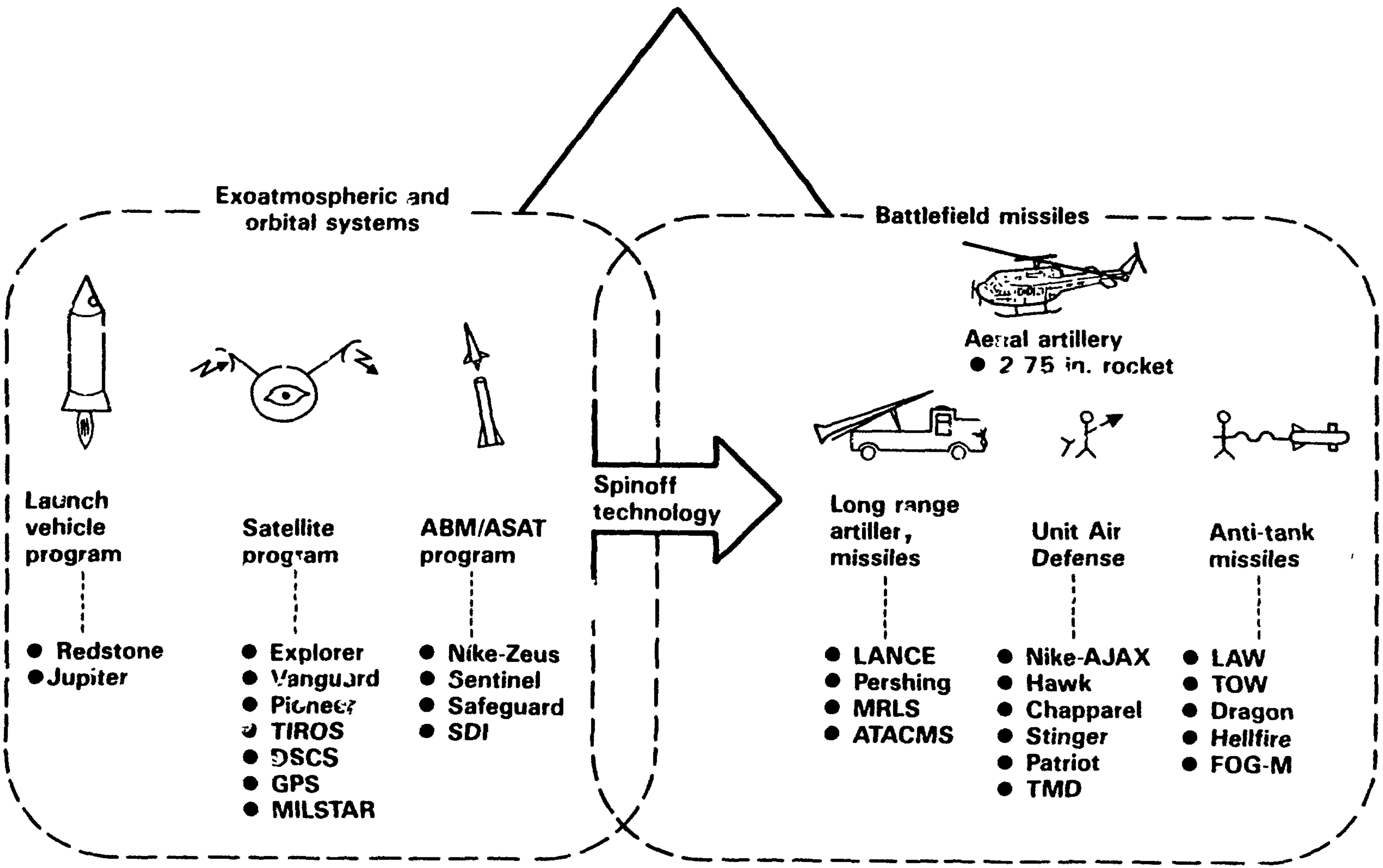

Fig. 4—Army space and battlefield missile arena

capital or one ICBM complex.[9] International treaties which offered cheap protection from space threats were the sixth constraining influence on Army exploitation of space during the perigee phase.

1961–1974 ARMY LONG-RANGE MISSILE DEVELOPMENTS

From 1961 through 1974, the Army developed or improved and then fielded seven nuclear-armed ballistic missiles. These force application systems were the improved Honest John, Phase II Littlejohn, Sergeant, Pershing, Pershing IA, Lance, and Pershing II. In general, these systems allowed the Army's missile artillery to grow from short-range, limited-mobility, dangerous liquid-propellant, non-guidable, 1950s technology, tactical rockets into long-range, air-transportable, ground-mobile, highly safe, solid-propellant, inertial-guided ballistic missiles.

The initial deployments of these rocket/missiles were as follows:

Improved Honest John	May 1961	solid-propellant	20 nm range
Phase II Littlejohn	September 1961	solid-propellant	10–20 nm range
Sergeant	September 1962	solid-propellant	75 nm range
Pershing	June 1962	solid-propellant	400/850 nm range
Pershing 1A	September 1969	solid-propellant	400/850 nm range
Lance	June 1973	liquid-propellant	75 nm range
R&D Pershing II	March 1974	solid-propellant	492 nm [10]

The improved Honest John was an air-transportable, truck-mounted, single-stage, solid-propellant tactical rocket with a range of about 20 nautical miles. The Littlejohn tactical rocket had comparable transport and range capabilities. The Sergeant was an air-transportable, solid-propellant ballistic missile with a range of about 75 nautical miles. It was transported in sections and then assembled and fired by an erector-launcher. The Pershing was the first Army missile not developed under the arsenal concept. It is an air-transportable, fast erector-mounted, two-stage, solid-propellant, central battery-controlled ballistic missile. Initially it had an approximate range of 400 miles but was improved

[9]Downey, p. 16; Stares, pp. 20, 165; Project History, p. 4-1.
[10]Jolliff, p. 239.

with later versions to over 850 miles range. The Lance is an air-transportable, track-mounted, single-stage, 2833-pound, liquid-propellant, 75-nautical-mile-range missile.[11]

1958–1972 ARMY SATELLITE AND GROUND STATION DEVELOPMENTS

From 1958 through 1972, the U.S. government greatly increased centralized control of space, intelligence, and communication efforts. NASA, ARPA, the Defense Communication Agency (DCA), the Defense Intelligence Agency (DIA), and the Defense Mapping Agency (DMA) were established and had varying constraining impacts upon how the Army exploited space during the perigee phase.

For example, after ARPA was formed in 1958, it began to develop an integrated national satellite tracking network by combining the three services' tracking assets. This effort was titled Project Shepherd and led to most Army-owned satellite and missile tracking assets being transferred to the Air Force and NASA. Similarly, NASA's published astronaut selection criteria in January 1959 required candidates to be test pilot qualified. This criterion prevented Army personnel from participating in early manned flights. Government reorganizations occurred in the early 1960s to improve management and the progress of reconnaissance satellite programs. For example, DCA was established to improve and regulate strategic armed forces long-distance communications. DIA was formed in 1961 to better coordinate military intelligence efforts. To gain improved military mapping, charting, and geodesy products, DMA was established in 1972.[12]

Secretary of Defense McNamara in 1961 used the authority granted him by the Reorganization Act of 1958 and the President's approval to centralize DoD's planning, budgeting, and operations. He issued DoD Directive 5160.32 in March to better control and coordinate satellite development and operations. This action removed the Army from launching satellites and from conducting DoD satellite reconnaissance efforts. The ground service, as a joint or tri-service member, was only allowed and funded to continue communication satellite and ground station efforts. However, McNamara cancelled the

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[11]"Army Missiles in Service and Under Development," *Army*, June 1973, pp. 19–21; N. L. Baker and R. M. Nolan, "1958 Was Year of Space Awakening for Nation," *Missiles and Rockets*, 29 December 1958.

[12]NASA JSC Education Brief #10013, Houston, TX, 1966, with information provided by T. Kovacevich, JSFC Historical Office, 24 January 1989; *MC&G . . . A Brief History of U.S. Mapmaking and the First Decade of the Defense Mapping Agency*, DMA, Washington, D.C., 1982, p. 18; Origins MSFC, pp. 16–18; Stares, p. 44, Burrows, p. 135; *A History of the Signal Corps*, p. 17.

ADVENT satellite program on 23 May 1962 because of delays in the USAF Centaur upper stage and other management difficulties.[13]

Providing long-haul communication support to theater commanders was one of the major ways the Army exploited space during the perigee phase. The Army directly contributed to designing the Synchronized Communication Network (SYNCOM), Initial Defense Communication Satellite Program (IDCSP), and the Defense Satellite Communication System (DSCS) ground station communication facilities that DoD/DCA fielded in the 1960s and 1970s. And between 1961 and 1967, the Army established and operated a global ring of satellite ground stations to provide reliable strategic communications to Army theater commands, such as USARV, Eighth U.S. Army, and NATO.[14]

Beginning as early as 1961, the Army operated fixed satellite ground terminals at Ft. Dix, New Jersey and Camp Roberts, California. In 1964, the Army established the Strategic Communications Command (STRATCOM) to operate the Army portion of the global Defense Communications System (DCS). STRATCOM acted as the single Army manager of long-haul communication support to theater commanders in the United States, Alaska, Europe, Central and South America, and Southeast Asia, as well as to the National Command Authority (NCA), U.S. Air Defense Command, civil defense communications, and non-defense communications.[15]

By the end of 1964, STRATCOM had developed, deployed, and operated additional theater mobile and fixed SYNCOM ground stations in Oahu, Hawaii; Clark AFB, Philippines; Saigon, Vietnam; Korat, Thailand; and Decomere-Guru, Ethiopia. On 2 October 1965, the Secretary of Defense established the DoD Tactical Satellite Communication Program (TACSATCOMP) and assigned the Army principal development responsibility for ground terminals and land vehicles. Also that year, the Army Satellite Communication Agency (SATCOMA) conducted R&D on first-generation, 3- to 6-foot diameter, parabolic tactical ground receivers. In 1966, Army-operated fixed ground stations were added to the SYNCOM network in Okinawa and Landstuhl, Germany. The Army began operating the Yong Son, Korea, ground station in 1967. By mid-1967, the Army operated all DCA/DoD SYNCOM and IDSC ground stations until it transferred the Clark AFB station to the USAF and the Oahu station to the

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[13]DoD Directive 5160.32, "Development of Space Systems," 6 March 1961; Matloff, p. 604; *Space and Missile Systems Organization: A Chronology, 1954–1979*, pp. 100, 107.

[14]Rolack, pp. 147–148, 155, 160.

[15]Rolack, p. 147; *A History of the Signal Corps*, p. 17.

Navy later that year. On 27 May 1970, the Deputy Secretary of Defense assigned the Army responsibility to determine ground station improvements and replacements for phase II DSCS. Also, the Army's Cobra Dane phased-array radar on Shemya Island and the Safeguard Perimeter Acquisition Radar were integrated into the USAF Space Detection and Tracking System (SPADATS) during the mid-1970s.[16]

An inducement to exploit space developed when Secretary of Defense Packard revised DoD 5160.32 on 8 September 1970. DoD recognized that each service had special satellite needs which would best be met by the interested service conducting its own R&D. The revised directive allowed each service to conduct research and, upon DoD approval, develop "unique" battlefield or ocean surveillance, communication, navigation, meteorological, mapping, charting, and geodesy satellite and technology programs.[17] Except for communication networks, little demonstrable Army capability sprang from the revised directive during the perigee phase of space exploitation.

1962–1976 ARMY AIR AND SPACE DEFENSE DEVELOPMENTS

During the 1960s and early 1970s, the Army continued rapid technological advancement of ABM and ASAT space control efforts. Advanced ABM capabilities were demonstrated 19 July 1962 when a Nike Zeus made the first successful U.S. intercept of an ICBM. This capability was only somewhat comforting later that year when the vulnerability of the United States to nuclear-armed IRBMs was clearly brought home to the American public during the Cuban Missile Crisis. Subsequently, in January 1963 Secretary of Defense McNamara directed the priority development of an ABM defense system and for the Army to re-orient the Nike Zeus approach to handle high-density ICBM attack employing chaff and decoys. This guidance led to Nike Zeus being renamed Nike-X in February 1964. That same year the Army's first electronically steered, phased-array radar went into operation at WSMR.[18]

Army ABM defense technology sufficiently progressed during the mid-1960s for the Johnson Administration, on 18 March 1967, to announce it was initiating the Sentinel continental defense program. This ABM defense system would initially engage enemy

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[16]*U.S. Army Tactical Satellite Communication Program (TACSATCOMP)*, Vol. 1, Executive Summary Department of the Army, Washington, D.C., 22 April 1974, introduction and pp. 1–5; LTC P. L. McGivern, "TACSATCOM for the U.S. Army," *Signal*, March 1974, p. 20; Rolack, pp. 147–148, 151–153, 160; Stares, pp. 132–133.

[17]DoD Directive 5160.32, "Development of Space Systems," 8 September 1970; Holdsworth, p. 18.

[18]Army Materiel Command General Order #4, 30 January 1964; Project History, pp. I-26, 1-36; Kwajalein, p. 55; Holm, p. 57.

ICBM-delivered warheads with nuclear-armed, long-range, exoatmospheric, three-stage, solid-propellant Spartan missiles followed by nuclear-armed, short-range, endoatmospheric, two-stage, solid-propellant Sprint missiles. The Spartan and Sprint missiles were outgrowths of the Nike Zeus and Nike-X research.[19]

To manage and field this new system, the Army established in 1967 the Sentinel System Command (SENSCOM). That same year the Army established the Ballistic Missile Defense Research Office to conduct follow-on ABM technology R&D. This latter organization was renamed the Army Advanced Ballistic Missile Defense Agency (ABMDA) in 1968.[20]

On 14 March 1969, the Nixon Administration renamed the Sentinel effort Safeguard and re-oriented it to primarily defend land-based U.S. ICBMs. In response, the Army replaced SENSCOM with the Safeguard System Command (SAFSCOM). R&D continued, and on 23 December 1970 the Army Sprint missile, #M1-12, made its first successful ICBM intercept at KMR. Three weeks later, the Army conducted the first successful salvo launch and intercept of a reentry vehicle during mission M1-30 at KMR.[21]

In 1972, the United States and the USSR signed the ABM Treaty limiting the location and size of deployed ABM defense systems. Army ABM R&D continued and in 1974 the Army formed the Ballistic Missile Defense Office (BMDO), converted SAFSCOM into the Ballistic Missile Defense System Command (BMDSCOM), and converted ABMDA into the Ballistic Missile Defense Advanced Technology Center (BMDATC). BMDO deployed the Safeguard system, which was activated and achieved full operating capability in 1975.[22]

Army ASAT R&D and operational efforts progressed simultaneously with its ABM work. In May 1962, Secretary of Defense McNamara instructed the Army to develop a nuclear-tipped, Nike Zeus ASAT defense capability. This effort grew into Operation Mudflap/Project 505. Subsequently, on 17 December 1962, the Army demonstrated it could fly an ABM missile within nuclear warhead kill distance of a simulated satellite timed to be at a point in space 100 miles above WSMR. Five months

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[19]"Missiles in Service," p. 16.

[20]Department of the Army General Order #48, 15 November 1968; R. Currie-McDaniel, *The U.S. Army Strategic Defense Command: Its History and Role in the Strategic Defense Initiative*, USASDC Historical Office, Huntsville, AL, 1987, p. 8; USASDC Historical Office, 31 July 89.

[21]Currie-McDaniel, pp. 8–9; Holm, p. 58; Project History, p. I-46; Kwajalein, p. 87.

[22]Currie-McDaniel, pp. 14–15; Project History, p. I-46.

later, on 24 May 1963, the Army conducted the first successful U.S. ground-launched intercept of an actual satellite with Mudflap missile #5. And in 1963 the Army deployed on Kwajalein Atoll a limited Mudflap anti-satellite defense system. Three years later the Soviets began testing co-orbital ASAT interceptor components. On 20 October 1968, they conducted their first space flight test when Cosmos #249 exploded after flying past Cosmos 248.[23]

Even though a Soviet co-orbital ASAT system existed, the Kwajalein Atoll ASAT defense system was deactivated in 1975 for two reasons. First, some American government officials felt that the 1972 SALT agreement not to interfere with national means of verification was sufficient to constrain Soviet ASAT efforts. And second, the 1975 deployed Safeguard ABM system had an inherent ASAT capability. Unfortunately, the debatable effectiveness of a limited and costly ABM defense combined with the Nixon Administration's belief that the 1963 and 1972 treaties would effectively discourage the Russians from interfering with U.S. satellites led the United States to begin deactivating its ABM operational forces in February 1976.[24]

Safeguard had appeared to be a high-water mark for Army ballistic missile and ASAT defense; but it was actually a mirage. And simultaneously the Russians did not behave as was hoped. In 1975, several U.S. satellites were blinded by an unidentified light source from the Soviet Union. Then on 16 February 1976, the Soviets resumed co-orbital ASAT testing with Cosmos 803.[25] With the deactivation of Safeguard, the U.S. had eliminated its only short response time, ground-launched ASAT capability.

Theater air defense efforts paralleled the Army's continental ABM R&D work on a more positive note. In May 1963, the SAM-D anti-aircraft missile feasibility study was initiated. This effort was later named Phased Array Tracking to Intercept of Target (PATRIOT) and experienced its first successful flight test on 27 February 1975.[26]

PERIGEE SUMMARY

During the perigee years of 1961 through 1976, the Army did not "lose" its lead in space exploitation. Instead it steadily advanced its ballistic missile force application capability, supported theater commanders by extensively developing and using

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[23]D.J. Durch, *National Interests and the Military Use of Space*, Ballinger Publishing Co., Cambridge, MA, 1984, p. 39; Stares, pp. 76, 114, 135–137; Project History, p. 1-31.

[24]Durch, p. 39; Downey, p. 66.

[25]Stares, pp. 213, 262.

[26]Information provided by Patriot program office, Huntsville, AL, 18 January 1989; Jolliff, pp. 72 241.

satellite/ground station-delivered long-haul communications, and deployed advanced ABM and ground-launched ASAT space control capabilities. Furthermore, the Army's substantial missile R&D effort of the 1950s provided the ground service and Marines with the technological basis to rapidly field small, lethal tactical missiles in NATO and Vietnam during the 1970s.

However, the ground service was forced to respond to powerful constraining influences which caused it to abandon satellite launches, to abandon reconnaissance satellite R&D and operations, and to deactivate its ASAT and ABM capabilities. Beginning in 1958 and ending in mid-1961, the Army transferred to NASA thousands of highly trained scientific and engineering personnel, significant missile R&D facilities, and major launch vehicle and satellite development programs. DoD's 1960 directive 5160.32 prevented the Army from performing reconnaissance satellite development, space launch, or space system operations. Furthermore, DoD centralization efforts constrained independent Army space efforts.

In Vietnam, the Army complied with its national role of conducting ground combat when called upon. There it spent over a decade fighting a theater ground war while paying little regard to space exploitation requirements. Instead it focused its high-technology efforts on developing less costly and more immediately helpful small, battlefield missiles. During the perigee phase the Army did exploit long-haul satellite/ground station communication capabilities but did so in a tri-service mode. The Army also pioneered ABM and ASAT technology advances, but by 1976 its ABM and ASAT operational units were dismantled. So by 1976, the Army had dropped to its lowest point, its perigee, in exploiting space.

IV. RECOVERY PHASE, 1977–1989

The Army's space exploitation recovery phase spans the time frame 1977 to 1989. Early in this period, the ground service emerged from the trauma of Vietnam and assessed how it would have to fight future wars while confronted by a USSR armed with a sophisticated space capability and a nuclear capability equal to that of the United States. This assessment produced the AirLand Battle Doctrine and the Concept-Based Requirements System (CBRS), which drove the Army's 1980s force structure and acquisition efforts. While assessing how to fight future wars, the Army's leaders became more aware of the importance of exploiting space and established a space organization infrastructure which worked to define future Army space exploitation efforts. Simultaneously, the Army exploited space:

- By continued development and deployment of deep attack ballistic missiles.
- By contributing to tri-service satellite/long-haul communication systems and networks.
- By conducting significant ABM and theater ballistic missile defense R&D.

1977–1989 THREAT AND NATIONAL POLICY

The United States faced a formidable and growing Soviet threat during the 1970s and 1980s. In the ICBM/nuclear arms arena, the strategic balance had clearly shifted in the Soviets' favor with their massive buildup of land-based nuclear forces during the 1970s. Specifically, from 1972 through 1982 the Soviets fielded improved SS-11s, 12s, 17s, 18s, and 19s while the United States restricted strategic force improvements. Such developments caused Secretary of Defense Brown to testify before the House Armed Services Committee in February 1979 that the U.S. land-based "ICBM survivability will have declined significantly by the early 1980s."[1]

In Europe, NATO was outnumbered and outgunned by Warsaw Pact forces which planned to win any land battle against allied countries by employing echelons of massed but mobile mechanized-armor-artillery forces.[2]

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[1] *Soviet Military Power: An Assessment of the Threat 1988*, DoD/U.S. Government Printing Office, April 1988, pp. 96–102.

[2] *Soviet Military Power*, pp. 37–39, 108–112.

In the space control arena, the Soviets had resumed ASAT testing and demonstrated again a successful operational capability by 1977. They also fielded, maintained, and then upgraded, near Moscow, the world's only operational ABM defense system (with an inherent ASAT capability) which employed networks of defense radars and nuclear-armed Gazelle and Galosh interceptor missiles.[3]

The Soviets also improved their ability to provide space support to their national and theater commanders by a steady buildup of their operational launch facilities, satellite inventory, booster inventory, and in-orbit satellites, including maintaining a manned presence in space aboard the MIR space station. By the late 1980s, they had developed nine reliable space launch boosters (SL4, 6, 8, 11, 13, 14, 16, X-17).[4]

Furthermore, in both friendly and threat nations, technological advances, stockpiles, and use of theater missiles greatly increased in the 1980s.[5] For example, approximately 800 missiles were fired at cities and other targets during the Iran-Iraq war. The USS Stark was almost sunk by an anti-ship missile in the Persian Gulf during that same war. Thus, U.S. ground and naval forces are vulnerable to destruction by current theater missiles and this vulnerability will worsen as the accuracy of such missiles improves.

So while the United States became increasingly dependent upon space-based assets, it faced an increasingly sophisticated adversary who had significant space support, space control, and force application capabilities. The possibility exists that quality improvements to the Soviet's quantitative space capabilities would guarantee the USSR a strategic military advantage should hostilities break out during the 1990s.

Over time the United States responded to the above-described threat. The Presidential and DoD national response included gradually recognizing the need for the military to be more active in space. The first example of this trend occurred in 1975 when the North American Air Defense Command (NORAD) was restructured and modified its name to the North American Aerospace Defense Command. The second example was in January 1977 when President Ford issued NSDM-345, committing the United States to development of an operational ASAT capability. The Army and USAF were subsequently funded to do advanced ASAT R&D.

After the end of the Vietnam War the Army developed and submitted to DoD a Reconnaissance Material Need Statement outlining the requirement for national satellite

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[3] *Soviet Military Power,* Preface and pp. 55–61; Stares, pp. 18, 262.
[4] *Soviet Military Power,* pp. 63–67, 98–99, 109–115.
[5] *Soviet Military Power,* pp. 21–23.

reconnaissance systems to provide tactical intelligence to ground forces.[6] Subsequently in 1977, Congress directed that the military services form Tactical Exploitation of National Capabilities (TENCAP) offices. The TENCAP program was designed to utilize, where applicable, existing national strategic satellite systems to support Army corps commanders and Naval commanders during theater operations.[7]

President Reagan entered office intent on improving America's national security. This resolve was demonstrated when President Reagan and Secretary of Defense Weinberger announced the Strategic Modernization Program 2 through 5 October 1981. This program was targeted to provide the United States with an effective, survivable early warning, communication and attack assessment system, while modernizing general U.S. space systems, while continuing development of an operational ASAT capability, and while improving civil and air defenses. The next year, on 4 July 1982, President Reagan announced a civil and military national space polic Then on 23 March 1983, President Reagan announced the Strategic Defense Initiative (SDI), shifting U.S. strategy away from offensive deterrence toward continental active defense. President Reagan on 11 February 1988 further coordinated U.S. space capabilities by announcing a major updating of the national space policy. The 1988 policy asserted the United States will maintain preeminence in key areas crucial to our national security, scientific, technical, economic, and foreign policy goals. It recognized and encouraged U.S. commercial development of space as well as coordinating military, civil, and commercial space efforts.[8]

DoD supported the President's strategy by forming the SDI Organization (SDIO) in 1983. The Army's BMDSCOM, which was converted into the U.S. Army Strategic Defense Command on 1 July 1985, began handling approximately one-third of SDIO's R&D effort. To further support the President's Strategic Modernization and SDI efforts, DoD formed the Unified Space Command on 23 September 1985. USSPACECOM provided the United States with a single operational command to employ space systems or systems associated with military space activities. Its primary responsibility is conducting space operations, surveillance, and early warning and ballistic missile defense

[6]Information provided by Mr. Lee Garrison, Army Space Institute, 20 October 1989.

[7]*Space Trace*, "Magna Carta Takes Focus," USSPACECOM, Peterson AFB, 18 July 1986, p. 4; *Supporting Data for FY1988/89, Budget Estimates: Research Development Test and Evaluation*, U.S. Department of Air Force, January 1987, p. 829; W. E. Burrows, *Deep Black: Space Espionage and National Security*, Random House, New York, 1986, p. 323.

[8]COLs J. Harvey and A. King, "Space: The Army's New High Ground," *Military Review*, July 1985, p. 40; Currie-McDaniel, p. 21; Stares, p. 217; Doyle, pp. 64–65.

planning. NORAD meanwhile continues to handle air attack defense. By early 1988, the Army, Navy, and Air Force each had a space command assigned to the unified command. USSPACECOM's three-service structure gives the United States the organization to conduct future space support, space control, and space force application should those missions be deemed necessary.[9]

To reduce nuclear missile threats, the United States signed the Intermediate-range Nuclear Forces (INF) treaty with the USSR in December 1987. In compliance with the treaty, the Army started withdrawing and destroying Pershing IRBMs on 1 September 1988.[10]

Finally, in January 1989, the Vice-Chairman of the Joint Chiefs of Staff coordinated the R&D development of a U.S. ASAT capability by approving a tri-service effort and assigning the Army as interim executive service for surface-based kinetic energy ASATs and with the USAF having responsibility for ASAT space surveillance and battle management. Formal documentation assigning this mission was signed by the Deputy Secretary of Defense in March. This authority led to the Army establishing the ASAT Joint Program Office (ASAT JPO).[11]

1977–1989 ARMY INFRASTRUCTURE RESPONSE

The Army's increased space exploitation activities during the 1970s and 1980s were part of the overall national response to the Soviet nuclear and space threat. The initial Army response emerged during its recuperation period after all U.S. troops left Vietnam in March 1973 and the subsequent collapse of the South Vietnamese government in 1975. This recuperation lasted approximately from 1974 through 1982. Part of it entailed assessing the Army's experience in Vietnam, the current and expected threat, and how it would fight in the future, as well as assessing how it was exploiting and should exploit space. The Army's resultant post-assessment actions demonstrate significant recovery in its interest in exploiting space and in the actual exploitation of space.

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[9]Bryant, pp. 7–8; Space Trace, p. 5; Stares, p. 220.

[10]Information provided by K. Hughes, MICOM Historical Office, 24 January 1989.

[11]W. Strobel, "Army to Manage the Development of Satellite-Killer," *Washington Times*, 13 January 1989; information supplied by MAJ Stephen C. Daly, Army Space Division, ODCSOPS, 30 May 1989 and 20 June 1989.

Doctrine

From 1978 through 1982, intense doctrinal activity occurred within the Army's Training and Doctrine Command (TRADOC), especially under its second commander, GEN Donn Starry.[12] At Ft. Leavenworth, the Army developed two complementary doctrines on how it should prepare for and fight the next war should deterrence fail.

The acquisition and preparation portion of the doctrine was established by 1 October 1980. It was a long-range materiel acquisition strategy which is currently known as the Army's Concept-Based Requirements System.[13] The purpose of the concept is for fighting doctrine based upon user-defined requirements, not technology, to drive what weapons systems, organizations, and training the Army purchases.

The keystone how-to-fight doctrine, FM 100-5, AirLand Battle, was published 20 August 1982. It detailed how the Army would fight operational and tactical battles against the current and emerging threat of the 1980s and early 1990s. The doctrine characterized the future battlefield as being dense with lethal weapons, as being non-linear, as having vulnerable communications, and as having vulnerable supply lines providing austere support to a supply-hungry force. Also, maneuver battles would be common, and U.S. forces would fight outnumbered.[14]

To win, the U.S. commanders would have to use real-time sensors to see deep into the enemy's rear and serve as a basis to target and attack follow-on forces. Then they would synchronize all available combat power and seize and retain the initiative by agilely striking at unexpected times and places throughout the depth of the battlefield. The U.S. forces would have to strike blows against critical units and areas whose loss would degrade the coherence of the enemy's operations rather than merely going against the enemy's leading formations.[15] FM 100-5 was revised and reissued in May 1986 and further emphasized the necessity of attacking echeloned enemy follow-on forces, including attacking them with missiles and Multiple Launch Rocket System (MLRS) artillery.[16]

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[12] Y. Ben-Horin and B. Schwartz, *Army 21 As the U.S. Army's Future Warfighting Concept: A Critical Review of Approach and Assumptions*, The RAND Corporation, Santa Monica, CA, R-3615-A, 1988, pp. 4–5.

[13] Ben-Horin, p. 8.

[14] FM 100-5, AirLand Battle, Command and General Staff College, Ft. Leavenworth, Kansas, 20 August 1982, pp. 1-1 through 1-3, 2-1 through 2-3.

[15] 1982 FM 100-5, p. 1-1, 2-1.

[16] FM 100-5, AirLand Battle Doctrine, Command and General Staff College, Ft. Leavenworth, Kansas. May 1986, p. 2–4, 16–20, 25.

The CBRS began working for the Army with the emergence of the Army's 1982 and 1986 AirLand Battle doctrine. The Army did not have the required weapon systems, organizations, or multiple service cooperation to see the battlefield in depth, attack deep, agilely maneuver outnumbered forces, or maintain command, control, and communication (C3) across and around the non-linear battlefield that it predicted it would have to fight on. The Army's fighting doctrine increasingly began driving its acquisition and materiel requirements for surveillance, C3, and attack systems for the late 1980s and beyond.

This doctrine still exists, and the land warfare requirements still exist. The requirements have influenced R&D on ground-based systems such as Guardrail, remotely piloted vehicles, the Forward Area Air Defense System (FAADS), and the Joint Surveillance Target Attack Radar System (JSTARS), as well as influencing space-based systems such as GPS,[17] and Military Strategic, Tactical and Relay (MILSTAR) communication satellite system. Not surprisingly, since 1982 Army personnel have increasingly looked upon space systems as potential means of providing the needed capability to implement AirLand Battle warfare.

In March 1989, the Combined Arms Center at Ft. Leavenworth further supported the importance of space capabilities to Army operations when it published the AirLand Battle Future Umbrella Concept (ALB-F). This document focused on the employment of the Army as the land component of U.S. military power in the early part of the 21st century. ALB-F takes a global military mission perspective and identifies eight regions which the United States must simultaneously address when it configures and equips forces and assigns missions. Of these eight regions, preservation of the United States is the most important one; space is identified as the second most important because of the critical support supplied by space assets to the successful prosecution of all U.S. military operations.[18]

Internal Reorganization and Mission Responsibilities

The Army has chosen an evolutionary approach to establishing an organizational infrastructure to exploit space.[19] Some individuals would criticize this approach as being unnecessarily slow. The Army's formal position is that expansion of space capabilities

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[17]Information provided by COL Bellamie, Army GPS Deputy, 21 November 1988.

[18]*AirLand Battle Future (ALB-F), Umbrella Concept, Draft*, Concepts and Force Alternatives Directorate, Ft. Leavenworth, Kansas, 31 March 1989, pp. 1, 7.

[19]Downey, p. 43.

requires orderly development, long-range planning, and deliberate action, followed by investment of Army resources.[20]

Recovery reorganization activity began with the formation in 1983 of the Army Space General Officer Working Group chaired by the Vice Chief of Staff. The group was to provide annual broad guidance for Army involvement in space. However, by the spring of 1984, the Army was the only service which had not established a strong central staff organization to manage its space activities. Space responsibilities were widely dispersed among numerous Army staff offices along functional lines. As a result of this fragmentation, Army participation in joint space matters was halting and poorly coordinated. Furthermore, that same year the Army Science Board concluded that the Army was only a minor user of available space systems, without a great deal of influence in the design and operation of the systems. The Army's space role and influence had declined as the importance of space to military operations grew.[21]

Significant organization and mission responsibility improvements occurred in 1985. In January, Headquarters Training and Doctrine Command directed the Commander, Combined Arms Command at Ft. Leavenworth to establish a space directorate. In May, the Office of the Deputy Chief of Staff for Operations and Plans (ODCSOPS) on the Army staff responded to the Army's poor space organization and utilization. The ODCSOPS directed the establishment of the Army Space Initiative Study (ASIS) group at Ft. Leavenworth to develop a blueprint for future Army involvement and investment in space through the first quarter of the 21st century. On 5 June, the Army Secretary and Chief of Staff mutually established Army space policy. This policy directed the use of space to enhance Army land-oriented operations and required future operational doctrine be developed to capitalize on space capabilities. On 1 July, the Army's ballistic missile defense organization was also streamlined and designated USASDC. It is the Army's single point of contact for SDI and ballistic missile defense matters.[22]

In August 1985, a classified interim operational concept was published by TRADOC titled Army Space Operations. Then, on 13 December, the ASIS group published its study, recommending the Army:

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[20]*Army Space Initiative Study*, Vol. 1, Executive Summary, Ft. Leavenworth, Kansas, 13 December 85, p. 22.

[21]Holdsworth, p. 52; Downey, pp. 40, 42; ASIS, p. 1.

[22]ASIS, pp. 1, 22; Bryant, pp. 6, 9, 10; information provided by Mr. Lee Garrison, Army Space Institute, 20 October 1989.

- Designate ODCSOPS as the senior staff proponent for space and monitor and implement a Space Master Plan.
- Form an Army Space Command as a part of USSPACECOM.
- Designate the Combined Arms Center (CAC) as the lead center for space and the Command and General Staff College as the lead school for space education.
- Integrate space into doctrine development.
- Make AMC responsible for developing the Army's technology base and managing space research.
- Fund numerous Mission Area Analyses related to space usage.
- Train Army personnel on space and establish a specialty indicator (3Y) for tracking space-qualified personnel.[23]

However, the report did not address ABM, ASAT, or TMD space control activities or issues.

After the ASIS report was published, many of its recommendations were implemented from 1986 through 1987. For example, the Space and Special Weapons Directorate was established on 20 June 1986 within ODCSOPS.[24] This Army staff office is now the focal point for integration of space policy, concepts, and requirements.

Also, the Army Space Institute was established in June 1986 within CAC at Ft. Leavenworth. ASI serves as the principal subordinate to TRADOC for educating the Army about space matters and is the space proponent within TRADOC. ASI is responsible for developing space concepts, doctrine, techniques, and procedures for applying space systems and space technology to land warfare.[25]

The Army Space Agency was established in August 1986 and in April 1988 was redesignated as the Army Space Command (USARSPACE), a component of the U.S. Space Command.[26] As a command, USARSPACE can be assigned operational units. Example future roles, when and if they are assigned to the Army, could be ground strategic defense of the United States, ground ASAT operations, or theater tactical surveillance and targeting. Example units could be an Army ground ABM unit, ASAT,

[23]ASIS, pp. 1, 8, 16, 17, 19.

[24]Information provided by DCSOPS SSW directorate Executive Officer, MAJ J. Jordan, 29 September 88.

[25]Information provided by ASI and Ft. Leavenworth Public Affairs Office, August 1988; Bryant, p. 9.

[26]Information provided by USSPACECOM Public Affairs Office, August 1988; Bryant, p. 8.

or a tactical satellite launch on demand organization. Figure 5 shows the current (1989) Army structure for space.

To staff the new Army space organizations with trained personnel, the Army established by 1986 qualification standards and training to receive an additional skill designator, 3Y. This designator can be used to track and assign space-qualified Army personnel to positions identified as requiring space expertise. However, 3Ys are not managed by an additional skill designator, so developing a pool of space expertise will be secondarily developed in branch and functional area qualified personnel.

Each of the Army space organizations assigned space roles and responsibilities (ODCSOPS, USARSPACE, ASI, USASDC, and AMC) began performing its assigned missions and contributing to the organizational debate about how the Army should exploit space. From this point on, Army space recovery contributions can best be understood as coming from one or more of the four organizational task areas: DA staff, user, combat developer, and materiel developer.

DA Staff Recovery Activities

During 1987 the Army Space Council and DA staff reviewed and approved an Army Space Concept and Army Space Master Plan. The 1987 Army Space Concept approved by the DA and currently in effect is:

- Enhance the Army's ability to execute AirLand Battle in joint and combined efforts, for all levels of war, across the full spectrum of conflict, by using space system capabilities.
- Leverage what is available now.
- Capitalize on developing programs.
- Initiate Army-tailored capability.[27]

In essence, this concept has two parts. The first is to aggressively pursue non-materiel areas which improve Army information gathering and decisionmaking about space. The second is to pursue a high-leverage acquisition strategy which resists the temptation to invest in space systems whose potential payoffs for the Army are not yet thoroughly understood.[28]

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[27]COL R. Ellis, *1988 Army Space Institute Briefing*.

[28]Elwyn Harris, *RAND Project 2762 (The Army's Role in Space), Progress Report*, RAND Engineering and Applied Science Department, Santa Monica, CA, 26 August 1986, pp. 7, 8.

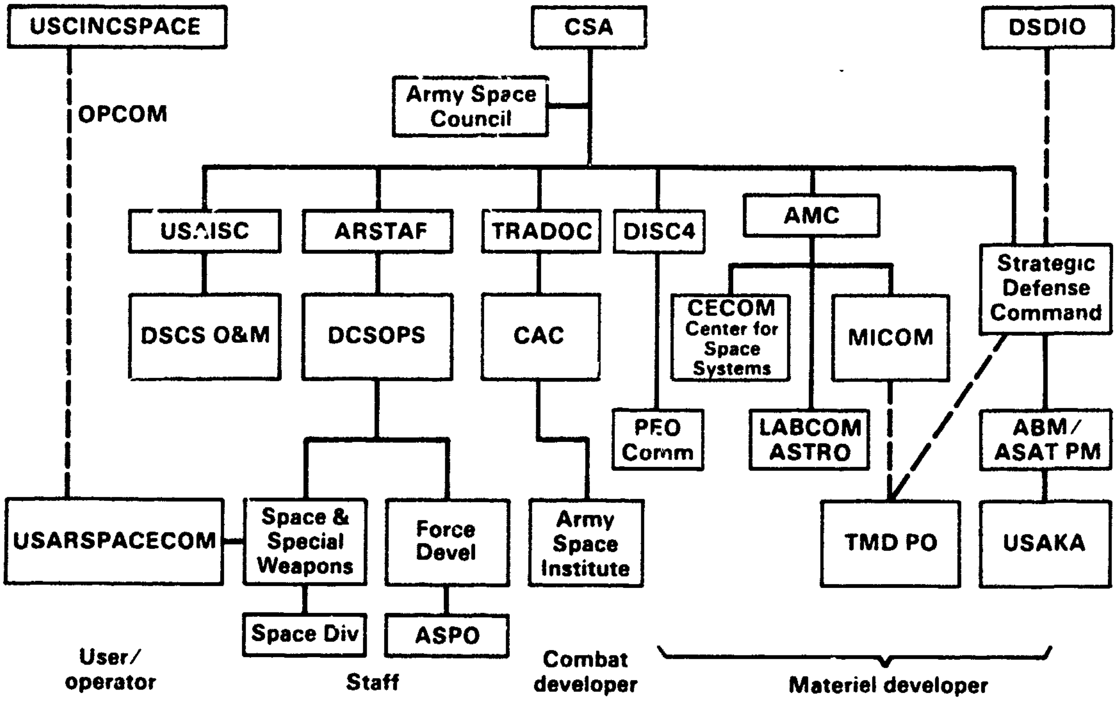

Fig. 5—Army structure for space

The space acquisition strategy, at best, will not supply new Army-tailored, dedicated launch, or space-based theater support for the next eleven years. This conclusion is based upon two assumptions. The first is that it will take the Army four years to demonstrate and define specific space asset requirements and then gain the approval and funds to pay for the assets. The second is that optimistically it will take seven years to design, develop, produce, and field the first asset. In effect then, any increased Army space utilization capability during the next decade will come about by better use of national or other service satellite-delivered information.

ODCSOPS and the Army Space Agency (later USARSPACE) worked together to develop an Army Master Plan. By the spring of 1987, the plan was approved and has subsequently been annually reviewed as a living document that will evolve as the need arises.[29] The purpose of the Master Plan was to establish and execute a process to exploit space activities that contribute to the successful execution of Army missions. This process would facilitate focusing the service's space efforts, developing space skilled personnel, funding valid requirements, and improving space acquisition efforts.[30]

The User Recovery Activities

USARSPACE during 1987 and 1988 began expanding from a small agency of 42 people into a command of several hundred. Simultaneously, USARSPACE was also responding to the DoD/JCS MILSATCOM Command and Control concept which significantly increased the USARSPACE missions and size through the transfer of the Defense Satellite Communication System (DSCS) mission from the U.S. Army Information System Command (USAISC).[31]

In the Center for Aerospace Analysis within USSPACECOM, Army LTC William Meiers pushed the development of a theater land engagement model (LEM-Space), which played space assets' contribution to ground combat. The author continued this effort in 1989–1990 by conducting analysis with the model and encouraging application of the model by DoD, USSPACECOM, and/or USARSPACE personnel to supply decisionmakers with model information that considered the utility of satellite constellations and ASAT capabilities to ground military operations.

[29]Information provided by COL B. Legge, Chief Army Space Division, DCSOPS, 6 October 1988.

[30]*Army Space Master Plan, Briefing*, MAJ R. Mason, 6 October 1986.

[31]COL J. Thurston, *GMF Manager and DSCSOC Transfer from USAISC to USARSPACE*, U.S. Space Command Point Paper, 10 June 88, pp. 80–82.

The Combat Developer Recovery Activities

ASI has demonstrated major initiative, intellectual innovation, and influence in getting the Army reinvolved in space. In March 1988, ASI published the draft U.S. Army Space Architecture. Figures 6 and 7, reproduced from the Army Space Architecture, display the general space requirements and six space capabilities needed to be acquired over time. The architecture further stated the basic acquisition strategy to be as follows:

- Exploit in the near term the available space-delivered information by buying ground receivers and proliferating them into Army units. (Get receivers)
- Acquire in the mid-term improved space/ground processing capabilities. (Get processors)
- Influence satellite design and operations simultaneously so in the long run the Army receives better space support. (Influence design and operations)

The draft architecture gives first-order cost estimates for the matrix of space capabilities, purporting that they could be purchased for $6.6 billion dollars.[32] The space architecture and acquisition strategy sig; ificantly helped articulate the types of force enhancement assets the Army could and should focus on. However, it should be noted that the early-1988 Army Space Architecture did not address any ASAT, ABM, TMD, or long-range missile requirements or components. As a consequence of the Army Space Architecture being a living document that is evolving as the need arises, later editions will incorporate these programs as appropriate.

Another effort ASI supported was developing space-qualified Army personnel. TRADOC was assigned 3Y proponency on 2 June 1986 and employs ASI to perform this responsibility. ASI helped define 3Y standards by 16 September 1987. ASI currently conducts a Space Action Officers Course to help train Army personnel working on space efforts. Also ASI is producing a course of study for the Command and General Staff College to be implemented in academic year 1989–1990. [33]

By June 1988, ASI had also written and was coordinating a draft Army space capstone doctrine titled Space Support for Army Operations, FM ASI-X1.[34] This

[32]*U.S. Army Space Architecture*, Draft, Army Space Institute, Ft. Leavenworth, Kansas, March 1988, pp. 1-2, 1-5, 9-6.

[33]Information provided by C. Kroll, ASI 3Y office, 19 October 1988 and Bryant, p. 7; information supplied by MAJ Stephen C. Daly, Army Space Division, ODCSOPS, 30 May 1989.

[34]FM 100-18 (Draft), *Space Support For Army Operations*, Draft, Department of the Army, June 1988.

- Communications
  - Enhance commander's ability to locate/track units and critical items
  - Enhance/augment communications in support of C^2
  - Enhance/augment communications in support of CSS
- Reconnaissance, surveillance, and tactical acquisition
  - Enhance commander's ability to see area of interest
  - Enhance commander's ability to target
- Weather and environment
  - Determine weather effects on unit and weapon system effectiveness
  - Provide terrain data for analysis and operational planning
  - Provide integrated weather/terrain effects
- Position location and navigation
  - Enhance ability to locate positions and navigate quickly and accurately
  - Enhance commander's ability to locate/track units and critical items
- Fire support
  - Provide capability to negate enemy satellites
  - Provide non-nuclear fire support capability from space
- Military man-in-space
  - Develop potential of manned platforms to enhance theater operations

Fig. 6—The Army space needs are listed by space category

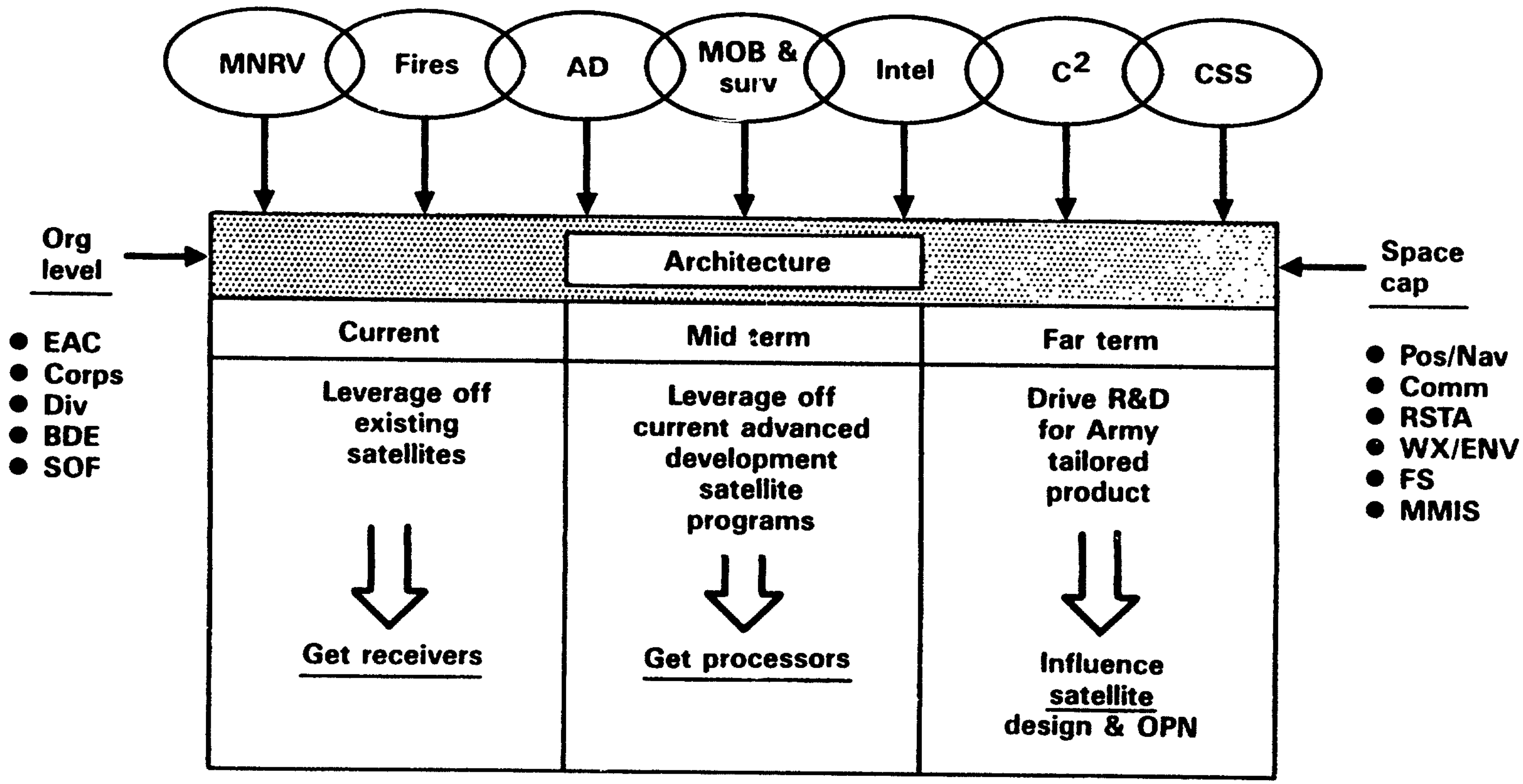

Fig. 7—The Army acquisition strategy for the space architecture

document presents national and Army space history, policy, and objectives, with little warfighting doctrine. However, the document does represent an initial attempt at specifying how the Army would fight with space assets and is currently under revision.

Throughout 1987 and into 1989, ASI also was actively involved in conducting a space demonstration program to enlighten field users to space capabilities, encourage requirement generation by field proponents, and immediately provide some interim weather information capability to the field. Beginning in FY88, the Army leveraged funding provided by the Defense Advanced Research Projects Agency (DARPA) to conduct research on inexpensive tactical satellites using simple, existing receivers. The Lightsats effort had $5,000,000 approved for expenditure 2 November 1988, with an anticipated demonstration in FY89.[35]

The Materiel Developer Recovery Activities

AMC responded to the ASIS and Army Master Plan by designating LABCOM as the lead space agency within that command while AMC's Missile Command (MICOM) at RSA would continue developing and fielding battlefield missile systems. The point of contact within LABCOM is the Army Space Technology Research Office (ASTRO). LABCOM, with ASTRO's assistance, performs headquarters oversight of the space technology program and ensures proper emphasis and funding are provided for space-related programs. ASTRO's influence comes from working for and advising the LABCOM commander, since the ASTRO office has been issued few funds and has no direct monetary control over Communications-Electronics Command (CECOM) or tri-service satellite and terminal efforts. A separate, tightly centralized space procurement organization within AMC was not initially established because of the immaturity of Army space technology. Instead, through mid-1988, AMC used commodity commands to conduct R&D of specific space technology.[36] However, LABCOM demonstrated additional support for developing space technology on 12 October 1988, when its Satellite Communication Agency (SATCOMA) was re-titled within CECOM as the Center for Space Systems and restructured with an expanded R&D mission to support Army, tri-service, and DoD space-based and space-dependent programs.[37]

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[35]ASI Space Action Officers Course, Ft. Leavenworth, Kansas, 1–2 November 1988; T. Foley and Logan, "U.S. Will Increase Lightsat Launch Rate to Demonstrate Military, Scientific Uses," *Aviation Week and Space Technology*, 26 September 1988, pp. 20–21.

[36]Information provided by COL D. Jackson, Chief ASTRO office, 11 October 1988.

[37]"Agency Receives New Commander, Mission," *Monmouth Message*, 7 October 1988.

But, AMC does not control all space-communication materiel development activities because the chain of command and control of communication systems program management money has been streamlined to flow through a Program Element Organization (PEO) outside of AMC. However, this is not to say that these organizations do not coordinate with each other.

In the ABM/SDI materiel developer area, BMDSCOM/USASDC's budget expanded from half a billion dollars in 1983 to $1 billion dollars per year by 1987 and $1.4 billion by 1989.[38] These monies were employed in ABM sensor (optical and radar); missile; directed energy; battle management/command, control, and communications (BM/C3); systems integration; and TMD R&D efforts, which represent significant areas where technological leveraging could be achieved in support of the Army space concept and acquisition strategy.

To accomplish such leveraging, USASDC established one person within its Office of the Chief Scientist to manage a $110,000 pilot contract to ensure technology is transferred into other Army efforts. Also, USASDC's formal mission requires the organization to spin off technology into the Army's theater missile/anti-tactical missile developments. And even though USASDC's regulation 10-1 does not address force enhancement or force application capabilities, it has cooperated with AMC in developing a Space Technology Exploitation Plan.[39] USASDC furthermore contributed to the space exploitation dialogue by developing SDI ABM and theater missile defense, organization, and operation plans during 1987 and 1988. And the Army has contributed DA funds to Kwajalein operations and maintenance, TMD, and ASAT JPO technology efforts. But it has not provided matching funds to USASDC's Office of the Chief Scientist to encourage or speed transfer of SDIO technology into the Army.[40] It appears that the Army will only pay for technology transfer when an Army project office has been assigned a DoD space or ballistic missile-type effort.

1977–1989 ARMY LONG-RANGE MISSILE DEVELOPMENTS

During the recovery phase, the Army continued improving and fielding the Lance, the Pershing IRBM, and a new Multiple Launch Rocket System.[41] The MLRS is

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[38]USASDC Historical Office, 3 July 1989.

[39]Information provided by COL T. Stong, USASDC technology transfer manager, Office of the Chief Scientist, 2 June 1989; *U.S. Army Strategic Defense Command Regulation 10-1*, 1 December 1987, Chap. 1, "Introduction," Chap. 3, "Mission and Major Functions of USASDC."

[40]Funding information provided by COL T. Stong, Office of the Chief Scientist, USASDC, 7 June 1989.

[41]Information provided by K. Hughes, MICOM Historical Office, 24 January 1989.

composed of a tracked mobile launcher which carries six solid-propellant tactical missiles (TACMS) that have nearly twice the payload and range of the Lance. These systems provided the Army with a capability to conduct conventional or nuclear deep attacks against enemy echeloned/follow-on forces. However, in compliance with the INF treaty, the Army began withdrawing the Pershing missile from Europe on 1 September 1988 for subsequent verified destruction. The removal of the Pershings influenced the United States to publicly begin urging NATO in 1989 to participate in a program to improve the survivability and effectiveness of the aging Lance missile launchers.

1977–1989 ARMY SATELLITE AND GROUND STATION DEVELOPMENTS

The first event helping the Army increase its satellite exploitation occurred in 1977 and 1978 when NASA modified its astronaut criteria by accepting scientist and mission specialist astronauts who did not have to be test pilot qualified. The new criterion allowed Army personnel to participate in manned space efforts. In August 1979, MAJ R. L. Stewart (later Brigadier General) was the first soldier selected to be an astronaut. LTC Stewart became the first soldier in space during Space Shuttle mission 41B 3-11 February 1984. The Army NASA Detachment was subsequently established at Johnson Space Center on 5 January 1987. That same year the Army requested from the DoD Military-Man-in-Space Prioritization Board permission to conduct the Terra Scout and Terra Geode space observation missions. These missions have been approved but not flown as of July 1989.[42]

In compliance with the 1977 directive from Congress, the Army established a TENCAP effort controlled by an office within ODCSOPS. This effort was later interfaced with the Army's mid-1980s Tactical Command and Control Systems (ATCCS) improvements, including intelligence fusion in the All Source Analysis System (ASAS)[43] and digitizing the data displays in tactical operating centers (TOC). Such effort would improve the utilization of available satellite-delivered information by corps and division TOCs.

CECOM and other Army elements also contributed during this period to such tri-service satellite and ground station materiel development efforts as DSCS, MILSTAR, and fielding the NAVSTAR/Ground Positioning System (GPS), for which the Army moved toward purchasing hundreds of GPS ground receivers.

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[42]Information provided by J. Kovacevich, JSFC Historical Office, 24 January 1989, with NASA JSC Education Brief #10013, Houston, TX, 1966; information provided by USARSPACECOM, 24 January 1989.

[43]BG W. E. Harmon, "Evolution and Progress: The All Source Analysis System/Enemy Situation Correlation Element," *Signal*, Issue No. 4, Vol. 42, December 1987, pp. 25–30.

In 1987, DoD transferred DSCS from the United States Army Information System Command to the Army Space Agency. In mid 1988, the Army Space Command gradually began taking over management of worldwide DSCS ground stations. Completion of the transition should occur in FY90. Along with handling the DSCS mission, USARSPACE has the lead in increasing the tactical use of DSCS capabilities.[44]

1977–1989 ARMY AIR AND SPACE DEFENSE DEVELOPMENTS

From 1977 through 1982, the Army steadily and quietly advanced ABM and ASAT technology R&D. BMDSCOM studied numerous defense options such as Site Defense, Low-Altitude Defense (LoAD), and Sentry to attempt to overcome land-based ICBM vulnerabilities. Because of the difficulties in defining a basing mode for the MX Peacekeeper missile, stabilizing an ABM defense concept was impossible during the late 1970s and early 1980s.[45]

In 1983, President Reagan's Strategic Defense Initiative (SDI) strategy provided a major boost to the Army's space activities, especially in the areas of ballistic and theater missile defense. From 1983 through 1985, USASDC annually managed approximately half a billion dollars of R&D funds and from 1986 through 1989 managed approximately \$1 billion.[46] Most of these monies were expended in the following space-related program element technology areas:

- Sensors.
- Battle management/command, control, and communications.
- Kinetic energy weapons.
- Directed energy weapons.
- Survivability and key technologies.
- Advanced technologies.
- Theater missile defense.

During 1983 and 1989, USASDC's SDI work fell into three R&D categories. The first was data collection conducted by projects such as Cobra Judy, a shipborne, S-band phased-array radar; and OAMP, an airborne X-band phased-array radar measurement

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[44]Thurston, pp. 81–82; information supplied by MAJ Stephen C. Daly, Army Space Division, ODCSOPS, 30 May 1989.

[45]Currie-McDaniel, pp. 19–23.

[46]Currie-McDaniel, p. 51.

program. The second category was evolutionary R&D as demonstrated by AOA, BM/C3, ERIS, HEDI, and TIR. The third category was revolutionary R&D such as White Horse NPB and GBL programs. These R&D efforts addressed the boost, post-boost, mid-course, and terminal phases of an ICBM attack against the United States.[47]

To effectively develop SDI technologies, the Army established the following program management programs and offices:

- 1983, High Endoatmospheric Defense Interceptor (HEDI).
- 1983, Homing Overlay Experiment (HOE).
- October 1983, Airborne Optical Adjunct (AOA), airborne sensor project.
- July 1984, Exoatmospheric Reentry-Vehicle Interceptor Subsystem (ERIS).
- July 1984, Terminal Imaging Radar (TIR).
- 1984, Battle Management/Command, Control & Communications.
- July 1985, USASDC was established with the above programs plus five SDI program element efforts:
  —SA/BM, Systems Analysis/Battle Management.
  —SATKA, Surveillance Acquisition, Track & Kill Assessment.
  —KEW, Kinetic Energy Weapons.
  —DEW, Directed Energy Weapons.
  —SLKT, Survivability, Lethality, & Key Technologies.
- 1986, Ground-Based Laser (GBL).[48]

The Army's ABM/SDI space activity and proficiency were increasingly recognized from 1983 through 1989. During the summer of 1983 BMDSCOM delivered the Defense In Depth study and results from its White Horse neutral particle beam (NPB) and HEDI high-altitude missile feasibility studies to SDIO.[49] Then, on 10 June 1984, BMDSCOM successfully conducted the ground-launched HOE missile flight test. This was the first major SDI success and the first time a nation had destroyed by direct kinetic impact a reentering ICBM warhead traveling in space.[50] In mid-1987, USASDC conducted for SDI the first real-time SATKA Integrated Experiment (SIE) using off-the-

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[47]Currie-McDaniel, pp. 2' 51–52.

[48]Currie-McDaniel, pp. 20, 29–30, 52–56.

[49]Currie-McDaniel, pp. 20, 29, 39.

[50]Information provided by Ballistic Missile Command HOE project manager, Mr. Ed Wilkenson, 28 September 1988; Currie-McDaniel, p. 20.

shelf sensor and battle management technology. The experiment successfully integrated a series of boost, mid-course, and terminal sensors tracking data, thus improving tracking accuracy.[51] In May 1988, USASDC took possession of the first DoD, reduced-size (.87 cubic feet), very high-speed integrated circuit (VHSIC) prototype computer processor developed under Army contract and supervision. And during June 1988, USASDC conducted the first major high-fidelity, real-time, SDI battle management simulations titled Experimental Version 1988 (EV88).

Recovery in the ASAT arena began after President Ford signed NSDM-345, on 18 January 1977, committing the United States to development of an operational ASAT capability.[52] The Army began conducting low-level R&D on ASAT technology in conjunction with its ABM research. The Army's HOE intercept technology was subsequently incorporated into the Air Force's F-15 ASAT weapon, directly contributing to that system's first successful intercept in 1985.[53] This system, however, was discontinued in 1988 when Congress refused to further fund its R&D. Because of the inherent capability of an exoatmospheric missile to easily conduct ASAT intercepts and because of the progress shown by the Army's ERIS program, the Vice-Chairman of the Joint Chiefs of Staff coordinated the R&D development of a U.S. ASAT capability by approving a tri-service effort and assigning the Army as interim executive service in January 1989.

The Army also applied missile and radar technology advances during the 1980s to overcome TMD vulnerabilities. Recovery activities in this technological arena were evident by 1985 with the deployment to Europe of an improved PATRIOT. Also in 1986, SDIO designated USASDC as lead service in TMD R&D. USASDC and MICOM began closely working together, with USASDC co-locating its TMD project office with the PATRIOT project office in Huntsville, Alabama.[54]

TMD proof of principle successes began on 20 April 1986 when USASDC's Flexible Lightweight Agile Guided Experiment (FLAGE) anti-theater missile successfully intercepted a tethered target. On 27 June 1986, the FLAGE missile successfully intercepted a free-flying target. Then on 21 May 1987, an inbound Lance

[51]Information provided by Mr. Sonny Dixon, USASDC SIE project manager, 27 September 88.

[52]Stares, p. 171.

[53]Information provided by Ballistic Missile Command HOE project manager, Mr. Ed Wilkenson, 28 September 1988.

[54]Information provided by the Patriot program office, Huntsville, AL, 18 January 1989; Currie-McDaniel, p. 59.

tactical missile was destroyed in flight by a FLAGE missile guided by a PATRIOT radar sensor. This experiment series confirmed the guidance and control accuracy required for non-nuclear intercept and destruction of a tactical ballistic missile within the atmosphere.[55]

Subsequently, USASDC in January 1987 awarded Phase I, multinational-European, TMD concept definition and architecture contracts to seven U.S. and allied teams. And by June 1988, USASDC began managing for SDIO two Israel-U.S. TMD R&D contracts.[56]

RECOVERY SUMMARY

The Army's recovery was initially slow from 1977 through 1982. Its emergence was first demonstrated by employment of both national and other services' post-Vietnam space assets within the TENCAP program. Development of the CBRS acquisition process and the AirLand Battle (ALB) Doctrine by 1982 represented the next recovery actions. ALB warfighting requirements supported the need to exploit space.

President Reagan's Strategic Defense Initiative greatly empowered and funded the Army in 1983 to unleash its expertise in pioneering ABM applications. The USASDC rapidly demonstrated its space skills through several successful sensor, missile, and battle management technology experiments. The 1983 through 1988 Homing Overlay Experiment, SATKA Integrated Experiments, EV88 BM/C3 simulations, and FLAGE missile interceptor tests were technology firsts reminiscent of the pioneering advances the Army was noted for during the 1950s.

Clearly, 1984 through 1989 was a watershed recovery period for the Army. By 1985 the Army had published an interim space operations concept and the Army Space Initiative Study (ASIS) report providing a vision of how to exploit space. During 1986 and 1987, the Army implemented the ASIS recommendations by developing a space concept, master plan, draft architecture, and acquisition strategy. It specified space exploitation missions and roles for the DA staff, for USARSPACE as user/operator, for ASI as combat developer, and for two materiel developer organizations, USASDC and Army Materiel Command (AMC). This reorganization established a proactive infrastructure which has and currently is performing the following space exploitation recovery tasks:

[55]USASDC's *1988 Army in Space and Strategic Defense* milestone chart; information provided by Mr. Claus Martel, USASDC historical office, August 1988.

[56]Information provided by USASDC PAO, 18 January 1989.

1. Debating and defining how the Army should exploit space during the 1980s and 1990s.
2. Developing doctrinal and operational concepts.
3. Providing a space command headquarters to execute missions and control operational units as they are defined and assigned.
4. Providing a cadre of space-qualified soldiers.
5. Providing requirements for system acquisition.
6. Participating in fielding new asset capabilities, such as the Global Positioning System.
7. Conducting R&D of ballistic missiles, tri-service and individual service satellite/ground station networks, and ABM, ASAT, and TMD systems.
8. Promoting Army space exploitation.

Even though the Army has not yet clearly defined the requirements for future Army-tailored space systems, its overall recovery actions reveal its growing space exploitation technology expertise, interest, and activity.

V. PROBLEMS HINDERING FUTURE PROGRESS

The Army's maturation during the 1984 through 1989 period in determining how to exploit space was quite remarkable. However, the Army is still confronted with four major problems that it has not yet overcome and that can hinder it from more fully utilizing space and successfully fielding a future force structure that adequately exploits space.

PROBLEM #1: THE ARMY DOES NOT HAVE A SPACE EXPLOITATION DOCTRINE

FM 100-18 (Draft), Space Support for Army Operations, was initially published in mid-1988 as a step in developing space exploitation doctrine. Unfortunately, this document primarily presents national and Army space history, policy, and objectives while dealing in a very limited way with space-supported warfighting doctrine. The mid-1989 AirLand Battle Future—Umbrella Concept was the second space exploitation doctrinal step. The ALB-F concept specified that space was the second most important region to the Army's crisis and warfighting capability because satellites were critical to the success of all global U.S. military operations.

Neither document, however, provides well-thought-out tactical and operational techniques for enhancing ground operations, space control, and force application equal to the arguments presented earlier in the century by military visionaries championing the benefits of fighting with the machine gun, the mechanized vehicle, or the airplane. The documents do not provide rationales for fighting high- and low-intensity conflicts with space-ground assets. Nor do they address ways to apply space networks to enhance strategic, operational, and tactical operations. Therefore, the ground service currently lacks an effective space exploitation doctrine.

Such a situation hinders the Army. First, without an effective space-air/land fighting doctrine, field forces will be constrained from fighting well because they have not prepared themselves mentally for handling conflicts employing available and future space assets. For example, theater commanders and their staffs, currently and in the near future, could inadvertently escalate the level of conflict between the United States and the USSR by mishandling a crisis when U.S. satellites are being interfered with by a USSR proxy or directly by the Soviets. In addition, counter to the Army's CBRS, it appears that technology rather than doctrine is the dominant force driving space architecture design and asset acquisition. Thus, Army acquisition personnel are constrained from prioritizing

asset acquisitions and delivering over time, within a limited budget, a highly effective combination of force enhancement, space control, or force application space assets to field commands.

PROBLEM #2: A LACK OF FIELD USER-GENERATED REQUIREMENTS FOR TACTICAL SPACE SUPPORT

Except in the area of long-haul communications, it is difficult to find branch or unit user-generated, "validated" requirements for theater support, theater space control, or space-supported force application systems. Little use of the LEM-S model has occurred to provide model information of satellite utility and input to system, technical, or operational requirements identification. There is no professional journal, such as the *Infantry Magazine*, to provide a forum for users to discuss requirements. Generally, there is a lack of trust or understanding of space assets by combat arms, combat service, and combat service support commands. Often the current satellite networks satisfy the strategic user; but significant shortfalls exist in employing the systems to help the theater commander concentrate forces or help the tactical commander perform maneuver and engagements. For example, some division officers are skeptical about TENCAP's utility because of the difficulty of access to timely, usable information to improve theater operations. Thus, there is only spotty demand for theater tactical space support.[1] The result of having few user requirements is that the Army has not yet developed a single space exploitation Required Operational Capability (ROC) and has only a few field proponents pushing for development of space support assets to overcome battlefield functional area weaknesses. However, user-generated requirements may increase as more Army field commands experience combat while using space systems or experience the ASI space demonstration program, thus gaining insight into the benefits of available space-delivered products.

PROBLEM #3: THE ARMY'S SPACE EXPLOITATION R&D AND ACQUISITION EFFORTS ARE ONLY PARTIALLY COORDINATED OR INTEGRATED

Current space exploitation R&D mission assignments within the Army have significant weaknesses in clarity and execution. Symptoms of this problem can be found by studying the responsibilities currently assigned to Army materiel and combat developers for implementing the space architecture and space acquisition strategy.

[1] Foley, p. 20.

The Army space architecture, as shown in Figure 7, calls for development, during three time frames lasting until the year 2000, of:

- Four enhancement capabilities: communication, weather and environment (WET), position/navigation (Pos/Nav), and military-man-in-space (MMIS).
- One force application capability: reconnaissance, surveillance, and target acquisition (RSTA).
- One space control capability: fire support, mainly meaning ASAT.[2]

But, this space architecture is incomplete because it:

- Does not address ASAT, ABM, TMD, or long-range ballistic missile organizations, doctrine, assets, operations, or R&D of space control capabilities.
- Does not address interfacing the space architecture into the larger Army ground force communication architecture at ATCCS interface nodes.
- Only provides a menu of capabilities without prioritizing those capabilities according to their utility for the battlefield commander or providing a procedure for determining which space capabilities should be purchased first or last during the three phases of acquisition. The architecture supports buying everything instead of buying a prioritized selection or portion of the available technologies and capabilities, depending upon available budget funds.
- Does not provide criteria or explain how space versus non-space asset alternatives will be compared and filtered when deciding what specific capabilities will be acquired.
- Does not address cost-benefit trade-off considerations.
- Lacks an explanation of how space asset alternatives will be transitioned into the Army acquisition system.

LABCOM has basically been given responsibility for the force enhancement capabilities described in the draft Army Space Architecture. The ODCSOPS TENCAP office has primary responsibility for the RSTA force application capability. Meanwhile,

[2]Draft Architecture, pp. 1-4 through 1-6.

USASDC and the ASAT JPO have been given co-responsibility for space control technology by splitting the SDI/ABM/ASAT efforts. USASDC and MICOM will co-develop TMD technologies. Therefore, the effectiveness of the Army's highly leveraged space acquisition strategy, including gaining program approval, is directly dependent upon how well ODCSOPS, LABCOM, CECOM, USASDC, ASAT JPO, and MICOM share technology, coordinate their funding requests, and argue their cases before the Defense Acquisition Board (DAB) or the Defense Review Board (DRB).

This author was also unable to locate DA guidance clarifying primary and supporting responsibility among the Army's major space exploitation players (USARSPACE, ASI, USASDC, ASAT JPO, CECOM, MICOM, & TENCAP office) for the three space exploitation capabilities to enhance ground forces, control space, and apply force. Nor was it clear who has lead responsibility for acquiring receivers or processors and influencing the design of the next generation of space assets. However, many of the technology efforts within the different commands have overlapping applicability across force enhancement, space control, and space control capabilities. But space exploitation technology R&D coordination is weak. For example, USASDC is doing significant sensor satellite work, while LABCOM'S CECOM is doing significant TOC automation and modernization work, as well as communication satellite work. Yet it is currently unclear which of these two organizations has primary and supporting responsibility for:

- Sensor satellite R&D.
- Weapon & targeting satellites R&D.
- Communication satellite R&D.
- Controlling interfaces among sensor, weapon and targeting, and communication satellites and ATCCS.

During 1988 and 1989, this author was unable to find an Army materiel developer organization which knew of or had developed an operational plan to implement the space architecture acquisition strategy of acquiring receivers, then processors, and influencing the next-generation space system designs. Some examples of acquisition planning which could not be found are:

- Procedures for prioritizing and gaining cooperative support between ABM, ASAT, TMD, tri-service satellite/ground station, TENCAP, and basic space research efforts.
- Procedures for integrated scheduling, funding, supervision, and design development, and interface resolution of receivers, processors, and future systems among space support, space control, and force application efforts or agencies handling such work.
- Plans for prioritizing and defining what types of receivers, processors, software languages, C3 network interfaces, or future systems were preferred.
- Procedures for identifying and communicating the major system design factors and interfaces which would limit or significantly influence receiver, processor, or future system designs.
- Procedures or management plans explaining how space receivers, processors, or future space systems would be interfaced into the digitized-automated tactical operation centers and C3 networks the Army is currently fielding.
- A criterion or a procedure to define a criterion for fairly judging the worth of specific non-space and space system technologies that are competing to meet a warfighting requirement.

In fact, it appears that the Army's space R&D expertise is technologically stovepiped and not mission capability focused. CECOM has space communication expertise but little ABM and mobile missile expertise, while USASDC has ABM expertise but little practical skill in global communication and mobile missiles launchers, and MICOM has mobile missile expertise but little ABM or global communication capability. This technological stovepiping is hindering cross-organization technology transfer, space architecture acquisition, and mission capability support.

Therefore, the Army will have a difficult task delivering one or more of the three space exploitation capabilities while managing the above-mentioned complicated organizational interfaces.

PROBLEM #4: THE ARMY IS RELUCTANTLY ADDRESSING THE ISSUE OF WHAT SPACE EXPLOITATION OPERATIONAL MISSIONS IT WILL FORSAKE OR PETITION DoD TO CONDUCT

Senior Army leaders do not have at this time critically important information and concepts for deciding what space-related missions would be best for the Army to pursue in an evolutionary manner. Examples of such information are the above-mentioned lack

of warfighting doctrine that explicitly exploits space and few user requirements for space. Part of the reluctance also exists because space-ground technology has historically been expensive to develop and operate. Any Army space exploitation missions will either be paid for out of the Army's current five-year budget or from supplemental DoD funds.

If the funds come out of only the Army's budget, space proponents will have to show that the value added by the space system outweighs the value added by more traditional Army units and operations. As the Army purchases space exploitation technology, it may have to buy fewer combat arms, combat support, or combat service support personnel or equipment. Such a situation would force Army leaders to develop and use some criteria to compare the contributions of traditional units and operations versus new space exploitation contributions and then decide which traditional units and operations would be reduced or eliminated. Such a criterion does not now appear to be developed or under development, thus slowing Army pursuit of space exploitation capabilities.

If the Army pushes for additional DoD funds, it will have to vigorously defend its budget requests against strong disagreements or challenges from the other services. Furthermore, without a convincing combat utility or national security explanation, it will be extremely difficult for space exploitation proponents to argue the merits of Army versus other service efforts or space versus nonspace options. These uncomfortable funding decisions and difficulties constrain rapid acquisition of space exploitation assets.

Another part of the operational mission and roles constraint is that space technology is rapidly advancing. If the Army delays in deciding and subsequently requesting appropriate space exploitation missions, then it is likely to squander valuable years when it could be conducting basic research and proof of principle operational experimentation. Lack of decisiveness on what Army space exploitation missions are necessary and beneficial to the country will limit 1990s R&D funding, will allow potential adversaries to advance their capabilities while we delay, and will expose the Army to future technological surprise.

However, there is a positive sign that indicates the Army is starting to address the operational mission constraint. USASDC, in late 1988 and early 1989, went to the Army's Vice Chief of Staff and then to the Defense Acquisition Board and successfully argued for the Army to be given the ASAT executive service role.

The four major problems described above could result in the Army purchasing a poorly integrated space exploitation capability by the year 2000. However, it is within the Army's control to overcome these constraints. It can rapidly develop a draft space

exploitation doctrine. It can conduct demonstrations and major exercises to help field commands gain a better understanding of operational capabilities that current space and non-space capabilities are not handling. Space exploitation requirements can be systematically evolved. The ground service can improve its space exploitation acquisition coordination and implementation. After these three improvements, senior leaders will be able to have the necessary information to choose which priority exploitation capabilities should be acquired or avoided.

FUTURE SUMMARY

Four problems are slowing the Army's exploitation of space:

1. Limited space exploitation doctrine.
2. Missing user requirements.
3. Poor acquisition coordination and implementation.
4. Reluctant acceptance or rejection by senior Army leaders of operational space exploitation missions and roles.

Lack of doctrine and missing user requirements prevent the ground service from specifying how best to fight with space assets and with what evolutionary priority these assets should be acquired.

The third problem exists because the service has not assigned in a systemic manner primary responsibility for simultaneously coordinating and conducting R&D of:

- The three space exploitation capabilities (i.e., enhance the ground force, space control, and force application).
- The three acquisition strategy tasks (i.e., get receivers, get processors, and influence future space system design).
- The numerous space technologies (i.e., RSTA, Pos/Nav, MMIS, communications, TMD, ASAT, ABM, etc.).

Furthermore, Army space exploitation materiel developers have not devised implementation plans to "get receivers, get processors, and influence systems designs and operations." It is therefore difficult for the Army to initiate and then maintain a rapid and efficient space exploitation acquisition effort. R&D responsibility weaknesses impede necessary coordination to reduce the cost of space exploitation research and hinder

effectively leveraging ongoing technology programs. Disjointed and overlapping R&D responsibilities tend to support an unsystematic development of Army-tailored space exploitation capabilities and piecemeal advocacy of separate space capabilities. It is currently more likely that commodity managers or major Army commands will harmfully compete among themselves for limited Army and DoD funds and support. Thus, developing a coherent, integrated space exploitation acquisition effort and gaining necessary funding from early 1990 DAB and DRB reviews appear unlikely unless this problem is overcome.

The first three problems, plus the high cost of space exploitation systems, fuel DA's reluctance to actively declare what operational space exploitation missions it is willing to forgo or actively pursue.

Appendix
CHRONOLOGY APPENDIX

Review of available space and missile history and chronology reports written prior to mid-1988 revealed only "stovepipe" chronologies reflecting only a portion of the historical Army space and missile efforts. No chronology existed that presented a systemic view, simultaneously addressing Army involvement in the following subjects:

1. *Policy and organization* chronology such as major national, Army, and other military service space policy events which significantly affected Army space participation and applications; national and Army space organizations; and Army space doctrine.
2. *Long-range missiles* chronology such as long-range artillery missiles, IRBMs, and space/ICBM boosters.
3. *Satellites* chronology such as satellite design, development, and launches.
4. *Ground station, radar, and communication* chronology such as Army communication networks, Army long-range radar efforts, and satellite communication and ground station network development.
5. *Air and space defense* chronology such as Army development and operation of high-altitude missiles, including anti-aircraft missiles, anti-missile missiles, anti-reentry vehicle missiles, and anti-satellite missiles.
6. *Small tactical missile* chronology such as employment of space missile technology spin-offs during the Vietnam War to the development of small Army tactical missiles including aerial rtillery, anti-tank, and low-altitude anti-aircraft missiles.

The chronologies that follow are structured to avoid the "stovepipe" problem by listing the historical events from 1907 through 1989 in the six broad categories listed above. The reader should be able to gain two insights:

1. A systemic understanding of Army development and exploitation of missile and space technology.

2. A clearer understanding of the evolutionary development of Army experience and capabilities in the technology areas of long-range/IRBM missiles, satellites, ground stations, and ballistic missile defense.

Four format techniques have been used to assist the reader's understanding of the trends within the chronologies. The first technique is that key words and titles are typed in **bold** type the initial time they occur to show the earliest time a policy, organization, technology, or weapon system appears in the chronology. The second technique is that the word **first** is typed in bold type for chronology entries explaining an Army missile or space technology breakthrough. This type is used to make it easier to recognize the numerous Army firsts in space exploitation that the service has achieved over the decades. The third technique is to sequence like subject events that occurred over time (such as the Army Explorer Satellite program) underneath a general title covering the period. These entries have a double ** preceding them. This formatting assists the reader in seeing the magnitude of multi-year, complementary events. The fourth technique is to repeat events first shown in Appendix A within Appendixes B through F. This technique enables the reader to see the impact of major policy or organization events upon technology development.

Appendix A

SPACE AND MISSILE POLICY AND ORGANIZATION CHRONOLOGY

1941–1945	**Army Signal Corps WWII** accomplishments: >>Virtually all the important radar equipment employed by the United States in combat up to the end of WWII, including the SCR-268 anti-aircraft radar, SCR 270 mobile long-range early-warning radar, and the complete radar equipment of the B-29s, is developed under the Signal Corps program. >>Develop, produce, and field major advances in multichannel signal/communication wire, cable, radio synchronization, and automatic encryption. >>By 1945, the **Signal Corps Army Communication Service** operates worldwide communication ground stations, the largest unified military communication system developed to date, composed of Army Communication and Administration System (**ACANS**) and Army Airways Communication System (**AACS**).
1943, Fall	Army establishes **Ordnance Rocket Branch** for central management of rockets in the same manner as other arms and munitions.
1944	Army establishes White Sands Proving Grounds (**WSPG**), NM.[1]
1945–1948	Army **Operation Paperclip** brings hundreds of German/Austrian rocket specialists to America.
1945, Nov	**General of the Armies H. H. Arnold** urges that the Army Air Forces start development of long-range ballistic missiles and space vehicles.[2]
1946, 29 May	The War Department Equipment Board (**Stillwell Board**) studies the needs of the post-WWII Army, identifying the need for the United States **not to be technologically surprised** in the future, and predicts a prominent role for **tactical missiles** in future warfare but calls for careful study of what types of missiles should be initially developed.[3]
1946, Dec	DoD accepts Chairman of R&D Board **Dr. V. Bush's** advice, dismissing most missile and satellite R&D, cutting the budget from $29 million to $13 million and 28 space

[1] Satterfield, p. 24.

[2] R. L. Perry, *Origins of the USAF Space Program, 1945–1956*, USAF Systems Command Historical Publication Series 62-24-10, Vol. V, 1961, p. vi.

[3] *War Department Equipment (Stillwell) Board Report*, U.S. Army, Washington, D.C., 29 May 1946, pp. 49–50.

	programs to eight. USAF loses its only ballistic missile program while the Army and Navy continue their ballistic missile research.[4]
1946	Army activates the Air Defense Command **(ADC)** to perform continental U.S. air defense.[5]
1947	National Security Act of 1947 establishes **DoD** and on 18 Sep 1947 the U.S. **Air Force** is officially created and activated.
1947, Fall	WSPG designs and proposes **Army** space flight experiment.[6]
1947, 19 Dec	**Joint Aeronautical R&D Board Committee** (Navy and AAF) on Guided Missiles acquires DoD responsibility for coordination and control of earth satellite vehicle programs.[7]
1948, 15 Jan	GEN H. S. Vandenberg issues policy statement on primacy of **USAF space interest,** stating that satellites are a logical extension of strategic air power and initiates low-level USAF satellite R&D.
1948, 16 Jan	Navy withdraws claim for control of satellite development.[8]
1948	SECDEF J. V. Forrestal completes military services negotiations on **missions and roles**: >>Army responsible for land operations, continental anti-aircraft defense, and overseas occupation and security forces. >>USAF responsible for strategic air warfare, air transport, and close air support to Army. >>Navy responsible for surface, sub-surface, and air operations at sea and control of the Marine Corps.[9]
1948, June	Russians initiate **Berlin Crisis.**
1949, 1 June	**Redstone Arsenal (RSA)** officially reactivated as the Ordnance Rocket Center, all ordnance rocket research and activities consolidated at RSA.[10]
1949, 3 Sept	A U.S. B29 weather reconnaissance aircraft detects radioactivity in Pacific, indicating the **first Soviet nuclear explosion** occurred sometime between 26 and 29 August.
1950, Nov	**Army** rocket research effort moved to RSA.

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[4]Stares, p. 27; Perry, pp. 14, 19, 21.
[5]"Magna Carta Takes Focus," *Space Trace*, USSPACECOM, Peterson AFB, 18 July 1986, p. 4.
[6]Perry, p. vii.
[7]Perry, p. vii.
[8]Perry, p. vii.
[9]Matloff, p. 532.
[10]Joiner, p. 2.

1952	President Truman establishes the National Security Agency (NSA) to handle the preponderance of signals intelligence.[11]
1952, 1 Dec	Ordnance Guided Missile School activated at RSA.[12]
1953, 16 Jun	SECDEF Wilson directs review of all guided missile programs with the objective of eliminating duplicative efforts.[13]
1953, Oct–Dec	U.S. intelligence reveals Soviets well along in development of an **ICBM,** triggering a major shift in national security policy and a **crash effort** to develop an American ICBM.
1953, Fall	DoD Guided Missile Study Group's Strategic Missile Evaluation Committee concludes that new warhead developments plus advances in rocket technology make an intercontinental missile (ICBM) immediately feasible.[14]
1954, 12 Jan	SECDEF J. F. Dulles announces in New York the U.S. Massive Retaliation policy (subsequently titled Mutually Assured Destruction, **MAD**).[15]
1954, 1 Mar	Congress approves U.S. participation in International Geophysical Year (**IGY**), 1957–1958 program.[16]
1954, May	Dept of Army decides to continue **Redstone** missile to gain early thermonuclear capability against Soviets.
1954	Joint Chiefs of Staff establish USAF Continental Air Defense Command (**CONAD**) as a unified command with ADC as a component.[17]
1955, 14 Feb	Technical Capability Panel (**Killian Committee**) recommends United States immediately develop a 1500-mile-range **IRBM** to parallel ICBM development and develop advanced reconnaissance satellite capabilities and advanced high-altitude reconnaissance aircraft (**U-2**).[18]
1955, 26 May	The **National Security Council** rules that military rockets (Army **Redstone** and USAF **Atlas**) may not be used in the U.S. scientific/IGY satellite program.
1955, 21 July	President Eisenhower proposes "Open Skies" plan to Soviets, British, and French at Geneva Summit.

[11] Burrows, p. 65.
[12] Joiner, p. 18.
[13] Perry, p. vii.
[14] Perry, p. 40.
[15] Brodie, p. 248.
[16] Perry, p. viii.
[17] Space Trace, p. 4.
[18] Grimwood, p. 5; Stares, p. 31; Burrows, p. 71.

1955, Aug	Army-Navy **Project Orbiter** proposal disapproved by the Assistant Secretary of Defense for R&D; he chooses the tri-service Navy-supervised **Vanguard** scientific (non-military) program to orbit the first U.S. satellite.[19]
1955, Sept	Army's Dr. **von Braun** recommends to DoD that the Redstone missile be used as the basis for a 1500 nm range IRBM.[20]
1955, 8 Nov	SECDEF assigns Army and Navy responsibility to develop land-based and shipboard IRBM capability.[21]
1955, Dec	SECDEF approves Army-Navy IRBM programs and President approves highest national development priority as long as IRBM program does not interfere with ICBM program.
1956, 1 Feb	Dept of Army forms Army Ballistic Missile Agency (**ABMA**) Class II activity at RSA to expedite development of a land-based IRBM, assigned responsibility for Redstone missile system.
1956, May	Special Assistant for Guided Missiles, SECDEF, refuses Army request that ABMA's Jupiter-C be an alternate to Vanguard.
1956, 26 Nov	SECDEF Wilson issues **military service missions and roles** statement: >>fixing Army responsibility with missiles having ranges of **200 miles or less**. Air Force to have responsibility for missiles having ranges of 200 miles or more. >>directing USAF to proceed with operational deployment of both the Jupiter and Thor IRBMs. >>fixing Army responsibility for "**point defense.**"[22]
1956	DoD establishes the Pentomic division and missile commands.[23]
1957, Aug	United States and Canada ratify the bi-national agreement forming the North American Air Defense Command (**NORAD**).[24]
1957, 27 Aug	USSR launches first successful **ICBM.**
1957, 4 Oct	USSR launches first earth orbiting satellite, **Sputnik 1.**
1957, 4 Oct	SECDEF McElroy briefed at RSA by General Medaris, Commander ABMA, on how soon the Army can launch a satellite.

[19]Satterfield, pp. 54, 55.
[20]Joiner, p. 74.
[21]Joiner, p. 58.
[22]Joiner, p. 74; *Chronology of the ABMA*, p. 11.
[23]Matloff, p. 584.
[24]Space Trace, p. 4.

1957, Oct	President approves continued Jupiter IRBM development in response to Soviet missile/space successes. Air Force assumes Jupiter program management.[25]
1957, 3 Nov	USSR launches second earth orbiting satellite, **Sputnik II,** weighing 1120 lb, clearly showing USSR capability to deliver ICBM-delivered nuclear warheads.
1957, 8 Nov	After repeated Vanguard failures, the SECDEF directs Army to attempt to orbit a U.S. satellite by March 1958.
1957, 27 Nov	SECDEF directs USAF to proceed with operational deployment of both Jupiter and Thor systems.[26]
1958, 23 Jan	**Senator L. B. Johnson's** Senate Armed Services Committee investigates why USSR beat United States into space, adopts 17 recommendations urging improved organization and management, and increases missile and space spending.
1958, 31 Jan	ABMA/JPL launch **Explorer I** aboard an Army Jupiter-C missile, **first** free-world earth-orbiting satellite.
1958, 7 Feb	DoD establishes the Advanced Research Projects Agency (**ARPA**), responsible for the **military** space program.
1958, 13 Feb	**NSC directive 5802/1,** U.S. Policy on Continental Defense, is published, recognizing need for continental defense system, importance of satellite defense, and need for vigorous R&D in these areas.
1958, 31 Mar	Army Ordnance Missile Command (**AOMC**) established at RSA, MG J. B. Medaris designated commander.[27]
1958, 20 June	**NSC directive 5814/1,** U.S. Policy on Outer Space, published, recognizing national security threat to United States of Soviet space achievements and the necessity to immediately develop a reconnaissance satellite.
1958	Congress passes the **Reorganization Act of 1958.**[28]
1958–1960	**NASA established,** responsible for **civil** space program.
**1958, 29 July	National Aeronautic Space Act creates NASA.
**1958, 1 Oct	NASA initially activated with 8000 NACA personnel, the **Vanguard** scientific satellite program, and 400 Naval Research Lab and ARPA personnel.

[25] Joiner, p. 76.
[26] ABMA Monograph #5, p. 29.
[27] Joiner, pp. 26, 79.
[28] Matloff, p. 604.

**1958, 3 Dec	Per Presidential directive, the Army transfers to NASA all **Jet Propulsion Lab** contract functions, facilities, land, and 2328 rocket and satellite specialists.[29] Army also transfers its **Redstone** rocket and **Explorer** satellite programs to NASA.
**1959, 8 Jan	NASA requests 8 Army Redstone Missiles for project Mercury (manned satellite).[30]
**1959, 13 Apr	DoD **Tiros** meteorological satellite program transferred to NASA.[31]
**1959, 18 Sept	ARPA transfers space projects to military services and begins conducting only basic research on advanced military technology.[32]
**1959, 21 Oct	President Eisenhower announces decision to transfer ABMA's **Development Operations Division** to NASA.[33]
**1959, 18 Nov	Army transfers its 1.5 million pound thrust **Saturn** missile project to NASA.
**1960, 14 Mar–1 July	ABMA Development Operations Division transferred to NASA, including von Braun team of 150 German scientists and engineers, 3900 ABMA personnel, 2500 skilled missile and satellite technicians and craftsmen, and 150 buildings.
**1960, 1 July	NASA **Marshall Space Flight Center** formally opened at RSA.[34]
1960, Mar–Sept	AOMC realigns personnel, missions, and roles after transfer of ABMA Development Operations Division. ABMA assumes responsibility of long-range artillery missiles and anti-tank weapons assigned Corporal, Sergeant, Honest John, Littlejohn, LAW, missile A, and missile B (Lance). **Army Rocket and Guided Missile Agency** assumes responsibility of air and space defense missiles and maneuverable missile systems, assigned Nike Ajax, Nike Zeus, Nike-Hecules, HAWK, Redeye, Mauler, and Shillelagh.[35]
1960	Defense Communication Agency (**DCA**) established to improve and regulate strategic, armed forces long-distance communications.
1961	SECDEF McNamara reorganizes DoD to establish centralized control of planning, budgeting, and operations.[36]

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[29]Nimmen, p. 11.

[30]Perry, pp. 18–19.

[31]ADM W. F. Boone, *NASA Office of Defense Affairs, The First Five Years, 1 December 1962–1 January 1969*, NASA, Washington, D.C., December 1970, p. 15; Perry, p. 19.

[32]Stares, p. 43.

[33]Nimmen, p. 380.

[34]Origins MSFC, p. 21.

[35]Joiner, pp. 124–127.

[36]Matloff, p. 604.

1961, 11 Jan	Unclassified **Wiesner committee** report published, declaring NASA, DoD, and three services poorly coordinate on space efforts.
1961, 6–28 Mar	**DoD Directive 5160.32,** Development of Space Systems, coordinates DoD satellite development by assigning the following responsibilities: >>Each service to conduct preliminary research to use satellite technology. >>Army to continue **ADVENT** communication satellite work. >>Navy to continue **TRANSIT** navigation satellite work. >>Air Force to perform satellite advanced R&D and operate all DoD reconnaissance satellites except **CIA/NSA** reconnaissance satellites. >>DoD to review and approve all advanced satellite R&D proposals.
1961, 25 May	Kennedy Administration announces national decision to land an American on the moon.[37]
1961	SECDEF McNamara establishes Defense Intelligence Agency (**DIA**).
1961–1973	U.S. Army fights war in **Vietnam.**
1962, 8 May	President approves DA and Army reorganization under authority of the **Reorganization Act of 1958,** most technical services eliminated, including Chief of Ordnance. Army Materiel Command (**AMC**) and Combat Development Command (CDC) established. AMC to handle acquisition and CDC to handle doctrine, requirements, materiel objectives, and cost-effectiveness.[38]
1962, 1 Aug	U.S. Missile Command (**MICOM**) established, as a subordinate command within AMC, by consolidating AOMC.[39]
1962, mid-Oct	**Cuban Missile Crisis.**
1962–1976	Space technology spin-offs used to develop conventional warfare missiles.
1963, 3–5 Jan	SECDEF McNamara directs the priority development of an ABM defense system. The Army to reorient the Nike Zeus effort toward a new system approach, i.e., **Nike-X;** which can handle high-traffic Soviet ICBM attack employing chaff and decoys.
1963, 10 Oct	U.S. Congress ratifies U.S.-USSR **Limited Test Ban Treaty** prohibiting nuclear explosions in outer space.
1967	U.S.-USSR sign the **Outer Space Treaty** banning nuclear and other mass destruction weapons from earth orbit or upon celestial bodies.
1967, 18 Mar	Johnson Administration initiates nuclear anti-ballistic missile, military-urban **Sentinel Defense Program.**

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[37]Nimmen, p. 4.
[38]Jolliff, p. 13.
[39]Jolliff, pp. 1, 10.

1967, 15 Nov	Sentinel System Command (**SENSCOM**) with the Sentinel System established under Army Chief of Staff as a class II DoD activity: SENSCOM takes responsibility/management of the Nike-X project from AMC.
1968, 30 Jun	Army Advanced Ballistic Missile Defense Agency (**ABMDA**) established as a class II DoD activity, SENSCOM Nike-X advanced research assigned to ABMDA.
1969, 14 Mar	Nixon Administration reorients Sentinel effort, renaming it **Safeguard** and employing long-range Spartan and short-range Sprint solid-propellant missiles to primarily defend land-based U.S. ICBMs. Safeguard System Command (**SAFSCOM**) established.[40]
1970, Jan	Presidential Space Task Group releases its Aeronautics and Space Report stating "DoD will embark on new military space programs only when they can clearly show that particular mission functions can be achieved in a more cost effective way than by using more conventional methods."[41]
1970, 8 Sept	**Revised DoD Directive 5160.32,** Development of Space Systems, assigns the following DoD satellite development responsibilities: >>Each service to conduct research and receive approval to develop the following type satellites: "unique battlefield and ocean surveillance, communication, navigation, meteorological, mapping, charting and geodesy satellites." >>Air Force to perform R&D, production, and deployment of the following systems: launch support, launch vehicles, warning and surveillance satellites of enemy nuclear delivery capabilities, and orbital support operations. >>DoD Director of Defense R&D to serve as focal point for space technology and systems to prevent unwarranted duplication, minimize technical risk and cost, and ensure multiple service needs are met.[42]
1972, Jan	Defense Mapping Agency (**DMA**) established by centralizing major military service mapping, charting, and geodetic assets. Services retain basic data gathering and R&D activities.[43]
1972, 26 May–3 Oct	U.S.-USSR sign the Anti-Ballistic Missile (**ABM**) Treaty limiting each country to one 100-missile ABM site and sign the Interim Agreement Strategic Arms Limitation Treaty (**SALT**) in which both parties agree not to interfere with national technical means (**NTM**) of verification.
1973–1976	Army supports South Vietnam and recovers from Vietnam War.

[40]Currie-McDaniel, pp. 8–9; Holm, p. 58; Project History, p. I-46.
[41]Stares, p. 159.
[42]DoD Directive #5610.32, 8 Sep 1970.
[43]MC&G, p. 18.

1974, 1 April — The Army Materiel Acquisition Review Committee (**AMARC**) concludes the Army's commodity command structure emphasizes readiness and impedes acquisition. AMARC's recommendations that separate readiness and acquisition commands be established is implemented by the Secretary of the Army.[44]

1974, 20 May — Ballistic Missile Defense Organization (**BMDO**) established by consolidating SAFSCOM and ABMDA ABM deployment/operations and advanced research activities. SAFSCOM redesignated Ballistic Missile Defense System Command (**BMDSCOM**). ABMDA redesignated Ballistic Missile Defense Advanced Technology Center (**BMDATC**).

1974, 3 July — Protocol-modified Article III of the ABM treaty signed in Moscow. Modification to go into effect on 24 May 1976.

1975 — Kwajalein Army ASAT system deactivated.

1975, Apr–Oct — Army **activates** Safeguard ABM system, IOC April 1957, FOC 1 Oct 1975. **First** U.S. deployed continental ABM defense system.[45]

1976, Feb — Army initiates Safeguard ABM system **deactivation.**

1977, 18 Jan — President Ford signs **NSDM-345** committing United States to development of an operational **ASAT** capability.

1977 — United States declares USSR has operational ASAT capability.

1977 — Congress directs services to form **TENCAP** offices.

1978–1982 — Army develops **AirLand Battle Doctrine**, published 20 Aug 1982.

1979, Feb — **SECDEF Brown** testifies before the House Armed Services Committee and states the U.S. land-based "ICBM survivability will have declined significantly by the early 1980s."[46]

1980, 1 Oct — Army establishes Concept-Based Requirements System (**CBRS**).

1981, May — Communication-Electronics Command (**CECOM**) established to ensure non-duplicative administration staff, and structured to ensure acquisitions will not be submerged to readiness as in the pre-AMARC period (pre-1974).[47]

1981, 2–5 Oct — President and SECDEF Weinberger announce **Strategic Modernization Program** to provide effective, survivable early warning, communication and attack assessment system, and modernization of general space systems. United States will pursue an operational ASAT system. Modernization involves strengthening the strategic nuclear

[44]Concise History of Ft Monmouth, p. 49.
[45]Currie-McDaniel, p. 15; Project History, p. I-49.
[46]Currie-McDaniel, p. 19.
[47]Concise History of Ft Monmouth, p. 51.

delivery triad by deploying MX/Peacekeeper missiles in hardened silos, rebuilding the C3 network, deploying B-1 and stealth bombers, deploying cruise missiles, continuing Trident submarine construction, deploying D-5 SLBMs, and improving air defense surveillance and civil defense.[48]

1982, 28 Feb	**High Frontier Strategy** published by Heritage Foundation arguing for a strong national active space defense with rapid deployment of a layered ABM system.[49]
1982, 4 July	President Reagan announces **National** (civil and military) **Space Policy** (NSDD-42).[50]
1982, 20 Aug	Army publishes FM 100-5, *Airland Battle Doctrine*.
1983	Army Space General Officer Working Group formed.
1983, 23 Mar	President Reagan announces the Strategic Defense Initiative (**SDI**) shifting U.S. strategy away from only offensive deterrence toward continental **active defense.**
1983, Apr	**Scowcroft Commission** publishes its modernization results, recommending vigorous BMD R&D but not deployment of an ABM system.[51]
1983, 1 Oct	DoD's **Miller/Hoffman Committee** completes its Future Security Strategy Study and recommends a multi-layered BMD and broad-based evolutionary R&D in support of SDI.[52]
1984, Feb	President Reagan's Defense Technologies Study Group (**Fletcher Panel**) completes its report and recommends a layered ballistic missile defense research in support of SDI.[53]
1985, Jan	**TRADOC** directs the Combined Arms Center to establish a space directorate.
1985, May	**ODCSOPS** constitutes Army Space Initiative Study Group.
1985, 5 June	Army SECDEF and Chief of Staff establish **Army Space Policy.**
1985, 1 July	**U.S. Army Strategic Defense Command** established.
1985, Aug	*Interim Space Operational Concept* published by the Army.
1985, 23 Sept	SECDEF establishes **Unified Space Command,** responsible for space operations, surveillance, early-warning, and BMD operational planning.[54]
1985, 13 Dec	*Army Space Initiative Study (ASIS)* published.

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[48] Currie-McDaniel, p. 21; Stares, p. 217.

[49] LTG D. O. Graham (USA Ret), *High Frontier: A National Strategy*, The Heritage Foundation, Washington, D.C., 28 February 1982.

[50] COLs J. Harvey and A. King, "Space: The Army's New High Ground," *Military Review*, July 1985, p. 40.

[51] Currie-McDaniel, p. 25.

[52] Currie-McDaniel, p. 28.

[53] Stares, p. 226.

[54] Bryant, p. 7; Space Trace, p. 5.

1986, May	FM 100-5, *Airland Battle*, doctrine updated.
1986, 2 June	**Army Space Institute** established at Ft. Leavenworth.
1986, 2 June	TRADOC assigned 3Y (space activities) proponency.
1986, 20 June	ODCSOPS designated space lead within Army staff.
1986, 1 Aug	**Army Space Agency** provisionally established.
1987, 10 Mar	**DoD Space Policy** published.[55]
1987, Spring	**Army Space Concept** approved by DA.
1987, 16 Sep	TRADOC establishes 3Y standards.[56]
1987, 8 Dec	U.S.-USSR sign the Intermediate-range Nuclear Forces (INF) treaty to reduce nuclear weapons in Europe and Russia.
1988, 11 Feb	President Reagan updates National (civil, military, commercial) Space Policy.[57]
1988, Mar	Draft **U.S. Army Space Architecture** published.
1988, 7 Apr	**Army Space Command** established within USSPACECOM.
1988, June	FM ASI-X1, *Space Support for Army Operations* **(Draft Army space doctrine)** published.
1988, 1 Sept	United States begins withdrawal and destruction of European **Pershing IRBMs** per the INF treaty.[58]
1989, 9 Jan	DoD acquisition czar R. Costello and the Vice Chairman, Joint Chiefs of Staff, approve the Army as **executive service/manager** of a $184.2 million joint service ASAT program including Army ERIS interceptors, lasers, and other beam weapons.[59] The deputy Secretary of Defense signs the documentation formally assigning the mission to the Army in March 1989.
1989, 31 Mar	The Combined Arms Center, Ft. Leavenworth, publishes **Airland Battle Future**, umbrella concept identifying space as the second most important region to the U.S. Army for conducting global military operations.

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[55] D. J. Johnson, p. 20.

[56] Information provided by ASI, 3Y proponency office, Mrs. C. Kroll, 19 October 88.

[57] S. Doyle, "U.S. National Space Policy Comprehensively Revised: A Commentary," *Journal of Space Law*, Vol. 16, No. 1, 1988, p. 64.

[58] Information provided by K. Hughes, MICOM Historical Office, 24 January 1989.

[59] Strobel, p. 7.

Appendix B

LONG-RANGE ARTILLERY/IRBM/ICBM MISSILE CHRONOLOGY

1918, Jan	U.S. Signal Corps commissions Dr. R. H. Goddard to develop military rockets, including long-range bombardment rockets.
1936	Army initiates rocket research in **Project ORDCIT** (Ordnance Department—California Institute of Technology) to conduct **first** unified U.S. investigation of rockets and related fields with intent to progress from test vehicles to a guided missile.
1942, 3 Oct	First successful launch of German **V-2** (Vengeance) missile.[60]
1943, Sept	Army establishes **Ordnance Rocket Branch** for central management of rockets, same as other arms and munitions. Ordnance Branch requests CIT study development of long-range surface-to-surface guided missiles.
1944, Jan	MG G. M. Barnes authorizes Project ORDCIT to conduct high-altitude rocket research.
1944, May	Ordnance Branch places $3.3 million contract with **CIT/Jet Propulsion Lab** for rocket propulsion and flight research leading to long-range missiles.
1944, 8 Sep	The first V-2 hits London.[61]
1944, 20 Nov	Army lets **Hermes** missile contract to General Electric to study how to best meet the needs of the Army Field Forces with **long-range artillery** missiles and high-altitude anti-aircraft missiles.
1944, 1–16 Dec	24 Army Ordnance/JPL solid-propellant **Private** step rockets are fired at Camp Irwin, California.
1944	Army establishes **White Sands Proving Grounds**, NM.
1945, 2 Jan	Army establishes the **first** large thrust rocket motor test station at Muroc, California, to test the **Corporal** 20,000 lb thrust motor.
1945, 24 Jan	Germans successfully launch A-9, a winged prototype of the first **ICBM** (A-10) designed to reach North America. A-9 reaches an altitude of nearly 50 miles.[62]
1945, 15 Apr	17 Army Ordnance/JPL Private missiles fired at **WSPG.**[63]
1945, May–June	COL H. N. Toftoy and MAJ J. P. Hamill execute **Operation Paperclip**. They remove hundreds of German/Austrian rocket experts, 100 nearly complete V-2s, and 300 train

[60]Brandt, p. 16.
[61]Perry, p. vi.
[62]Origins MFSC, p. 4.
[63]Satterfield, p. 39.

	carloads of rocket material and documents from Nordhausen in Harz mountains just prior to Russian occupat on of that sector.
1945, Fall	Army conducts first large thrust rocket motor test at Muroc, California.[64]
1945, 26 Sept	**First** successful developmental flight of large, American/U.S. government-funded, liquid-propellent rocket, the Army/JPL **WAC-Corporal** at WSPG. Achieves 43-mile altitude.
1945, 19 Oct	JPL deeds to the U.S. Army 31.5 acres and facilities in California, making the U.S. government **owner** of the Jet Propulsion Laboratory (**JPL**).
1945, Oct	Army activates the 1st Guided Missile battalion at Ft. Bliss, Texas.[65]
1945, Nov	**General of the Armies H. H. Arnold** urges that the Army Air Forces start development of long-range ballistic missiles.
1945, Dec	120 captured German V-2 scientists arrive at WSPG.
1946	Ordnance R&D **Rocket Sub-office** is established at Ft. Bliss, with MAJ J. P. Hamill as director.[66]
1946, 22 Mar	Army WAC-Corporal missile flies to an altitude of 50 miles, **first** American rocket to escape earth's atmosphere.[67]
1946, 16 Apr	Army **von Braun team** begins flight testing captured V-2 rockets at WSPG.[68]
1946, June	General Electric begins **Hermes C1** ballistic missile feasibility study.[69]
1946, Dec	DoD accepts Chairman of R&D Board **Dr. V. Bush's** advice, dismissing most missile and satellite R&D, cutting the FY47 guided missile budget from $29 million to $13 million and 28 space programs to eight. USAF loses its only ballistic missile program while the Army and Navy continue their ballistic missile research.
1947, 22 May	First full-scale flight test of **Corporal-E**, **first** U.S. surface-to-surface ballistic missile; it accurately flies 63 miles.[70]
1947, 6 Sept	Army Ordnance cooperates with the Navy in an experimental firing of a V-2 from the deck of the **USS Midway**.[71]
1947, 18 Sep	The U.S. **Air Force** officially activated.

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[64]Corporal Monograph #4, p. xiii.
[65]Satterfield, p. 24.
[66]Joiner, p. 3.
[67]Nimmen, p. 353.
[68]Nimmen, p. 353.
[69]Joiner, p. 40.
[70]Origins MSFC, p. 7; Corporal Monograph, p. xiv.
[71]Perry, p. 8.

1948, 13 May	Army **Bumper/WAC-Corporal** missile fired at WSPG, **first** U.S. use of **spin rocket** to provide aerodynamic stabilization. Contractor support provided by JPL and General Electric.[72]
1948, 18 May	A total of **492** Project Paperclip German/Austrian rocket specialists arrive in United States, distributed as follows: **177** to Army, **205** to Air Force, **72** to Navy, **38** to Commerce Department.
1948, 15 Sep	Committee on Guided Missile R&D Board approves Army's Hermes project and provides "the National Military Establishment with a continuing analysis of the long-range rocket problem."[73]
1949	Chief of the Army Field Forces reconvenes the **Army Field Forces Board #4** and directs it to study the broader aspects of tactical surface-to-surface missiles having a range capability fo **500 miles.**[74]
1949, 24 Feb	Army/JPL Bumper missile (WAC-Corporal and V-2) launched to 244-mile altitude—world's **first** multi-stage (2) liquid-propellant rocket, **first** American rocket to enter orbital space, and **first** missile to send telemetry data from space to ground stations. Bumper missile design solved stage-separation problem and the in-flight rocket motor ignition problem.[75]
1949, 3 May	First successful Navy **Viking** flight achieves 50-mile altitude, launched at WSPG.[76]
1949, 3 Sept	A U.S. B29 weather reconnaissance aircraft detects radioactivity in Pacific, indicating the first **Soviet nuclear explosion** occurred sometime between 26 and 29 August.
1949, 22 Sept	Chief of Ordnance selects the **Corporal E** to be developed into the **first** U.S. tactical guided missile.[77]
1950, 28 Jan	Army completes last of 52 WSPG V-2 firings, including the **Albert monkey flights.**[78]
1950, 3 May	Army Ordnance initiates **Honest John** surface-to-surface, solid-propellant, missile system.[79]
1950, 24 July	Bumper #8 launches **first** missile at **Cape Canaveral.**[80]

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[72] *Hermes and Rocket Programs, Ordnance Guided Missile*, Vol. X, Redstone Arsenal, Chap. II, p. 11.

[73] Perry, p. 8.

[74] Bullard, p. 21.

[75] Nimmen, p. 353; Joiner, p. 39; Bullard, p. 11.

[76] W. Ley, *Rockets, Missiles and Space Travel*, Viking Press, New York, 1958, p. 461.

[77] Corporal Monograph #4, p. xv.

[78] Nimmen, p. 353.

[79] Perry, p. 9.

[80] Origins MSFC, p. 10.

1950, July–Aug	Office, Chief of Ordnance, transfers Hermes C1 study to **Redstone Arsenal (RSA)** and directs RSA to study 500 nm range, 2000 lb warhead, surface-to-surface missile (missile named **Redstone,** 8 Apr 1952).
1950, Nov	Army WSPG rocket research effort moved to RSA.
1950, Dec	Corporal **first** U.S. missile to be approved as an atomic warhead carrier.[81]
1951	Army completes construction of two supersonic wind tunnels (12 inch/Mach 3.5 and 20 inch/Mach 4.8) for missile testing, among the first such tunnels in the United States.[82]
1951, 16–23 Jan	USAF establishes project MX-1953 **(Project Atlas) ICBM** study contract.[83]
1951, Feb	COL H. N. Toftoy, Chief of the Rocket Branch, Office Chief of Ordnance increases Redstone missile payload weight sufficient to handle the existing atomic 6900 lb warheads, thus decreasing its range to **200 nm.**
1951, 10 July	RSA becomes responsible for maintaining pilot production lines for manufacture and/or assembly of rocket and guided missile components and end items. 27 Oct 1952, RSA fabricates first 12 Redstone rockets.[84]
1951, 7 Aug	Navy **Viking 7** rocket sets an altitude record for single-stage rockets, climbing to 136 miles above WSPG.[85]
1951, 16 Aug	Office, Chief of Ordnance, assigns RSA with JPL responsibility for development of the interim, surface-to-surface, guided missile system titled **Corporal** (Corporal evolution = Project ORDCIT, Private A and F, WAC-Corporal A and B, Bumper, then Corporal).[86]
1951, Aug	First Honest John firing test conducted.[87]
1952, Mar	Three Corporal missile battalions activated, **first** U.S. ballistic missile units.
1953	Atomic Energy Commission (AEC) announces technological breakthroughs in **nuclear warhead** design, allowing significantly smaller/lighter warheads.[88]
1953	Army develops **first** U.S. missile inertial guidance system and is **first** user of transistorized components in ballistic missiles, greatly improving missile accuracy and reliability.[89]

[81] Corporal Monograph #4, p. xv.
[82] Corporal Monograph #4, p. xvi.
[83] Perry, p. 10.
[84] Joiner, pp. 8, 40–41.
[85] Perry, p. 11.
[86] Joiner, pp. 41–42.
[87] "Missiles in Service," p. 21.
[88] F. Gibney, "The Missile Mess," *Harper's Magazine*, January 1969, p. 1.
[89] Medaris, Significant Achievements.

1953, 5 June	Missile fired out of an **Army Corps of Engineers**-constructed underground launcher installation/**silo.**[90]
1953, 16 Jun	SECDEF Wilson directs review of all guided missile programs with the objective of eliminating duplicative efforts.
1953, 20 Aug	RSA Guided Missile Development Division, Missile Firing Lab successfully launches the first Redstone missile, from Cape Canaveral, **first** successful heavy ballistic missile launch.
1953, Oct–Dec	U.S. intelligence reveals Soviets well along in development of an **ICBM,** triggering a major shift in national security policy and a **crash effort** to develop an American ICBM.
1953, Fall	DoD Guided Missile Study Group's Strategic Missile Evaluation Committee concludes that new warhead developments plus advances in rocket technology make an intercontinental missile (ICBM) immediately feasible.
1954, May	Dept of Army decides to continue Redstone missile to gain early **thermonuclear capability** against Soviets.
1954, Jun	M31 Honest John-deployed, **first**/interim U.S. tactical nuclear weapon issued to Army Field Artillery units.[91]
1954, July	Corporal deployed.
1954, Nov	259th Field Artillery Missile Battalion (Corporal) becomes **first** U.S. operational ballistic missile unit, **first** U.S. missile unit deployed overseas, to the U.S. 7th Army in **Europe**, in Feb 1955.[92]
1955, 1 Jan	Ordnance formally initiates **solid-propellant**, **Sergeant** missile project, assigns RSA/JPL technical responsibility; this is a short-range, surface-to-surface replacement missile for the Corporal.[93]
1955, Jan	Air Force confirms it has contracted to develop **Atlas**, 5000-mile, liquid-propellant ICBM.[94]
1955, 14 Feb	Technical Capability Panel (**Killian Committee**) recommends U.S. immediately develop a 1500-mile range **IRBM** to parallel ICBM development.
1955, Sept	Army's **Dr. von Braun** recommends to DoD that the Redstone missile be used as the basis for a 1500 nm range IRBM.

[90]Perry, p. 12.
[91]Joiner, p. 34.
[92]Corporal Monograph #4, p. xviii.
[93]Joiner, p. 46.
[94]Grimwood, p. 4.

1955, 8 Sept	SECDEF approves **Jupiter** (Redstone derivative) and Thor (Atlas derivative) IRBM programs.
1955, 8 Nov	SECDEF assigns Army and Navy responsibility to develop land-based and shipboard IRBM capability.
1956, 1 Feb	Dept of Army forms Army Ballistic Missile Agency (**ABMA**), including the **Development Operations Division** at RSA to expedite development of a land-based four-stage IRBM (later named Jupiter) and assigns responsibility for Redstone missile system.[95]
1956, Apr	First Redstone field artillery missile group (the 40th) activated, attached to ABMA at RSA.[96]
1956, 14 Mar	ABMA launches first Jupiter A, Cape Canaveral.
1956, 20 Sept	**Jupiter-C missile #RS-27, first** three-stage missile, launches nose cone to 682-mile altitude, 3335-mile range.
1956, 1 Oct	Army contract proposal published for FBM-Jupiter submarine application.[97]
1956 26–27 Nov	SECDEF Wilson issues **military service missions and roles** statement fixing Army responsibility for missiles having ranges of **200 miles or less**, Air Force to have responsibility for missiles having ranges of 200 miles or more. SECDEF directs USAF to proceed with operational deployment of both the Jupiter and Thor IRBMs.
1956, 8 Dec	SECDEF authorizes Navy to proceed with solid-propellant **POLARIS** IRBM.[98]
1956	DoD establishes the **Pentomic division** and missile commands. Divisions are directly supported by artillery and missiles that can employ conventional or nuclear warheads. Heavier long-range missiles are consolidated in missile commands.
1957, 7 Jan	Commanding General ABMA briefs **Senator Lyndon Johnson's** Congressional Subcommittee on ABMA's capability to build a mobile, solid-propellant **MRBM** smaller than the Jupiter.[99]
1957, 8 Feb	USAF Western Development Division (responsible for development of the Atlas) replies to Air Staff queries and states only maximum risk launches can be made during 1958 and no success assurances could be given until mid-1959, assuming excellent development progress.[100]

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[95]Joiner pp. 59, 74, 77.
[96]Joiner p. 73.
[97]*Chronology of the ABMA*, p. 9.
[98]*Chronology of the ABMA*, p. 12.
[99]*Chronology of the ABMA*, p. 14.
[100]Perry, p. 54.

1957, Apr	ABMA/von Braun team begins studies of 6000–12,000 lb payload booster (**Juno** which led to **Saturn**), America's **first** rocket developed for space investigation.
1957, 31 May	Jupiter missile #AM-1 is the **first** successful free world **IRBM** firing; it flew downrange 1147 nm.[101]
1957, 27 Aug	USSR launches first successful **ICBM.**
1957, Oct	President approves continued Jupiter IRBM development in response to Soviet missile/space successes. Air Force assumes Jupiter program management.
1957, 3 Nov	USSR launches second earth orbiting satellite, **Sputnik II**, weighing 1120 lb, clearly showing USSR capability to deliver ICBM-carried nuclear warheads.
1957, Dec	ABMA proposes to DoD development of a 1.5 million lb booster.[102]
1957, 17 Dec	First U.S. successful short-range firing of the USAF Atlas ICBM, 500-mile flight.[103]
1958, 7 Jan	SECDEF assigns Army responsibility to develop **Pershing** solid-propellant missile as a follow-on to the Redstone missile.
1958, 17 Jan	First launch of Navy Polaris test vehicle, Cape Canaveral.[104]
1958 7 Feb	DoD establishes the Advanced Research Projects Agency (**ARPA**), responsible for the **military** space program.
1958, 31 Mar	Army Ordnance Missile Command (**AOMC**) established at RSA, MG J. B. Medaris designated commander.
1958, 31 Mar	ABMA begins training the first Strategic Air Command (SAC) Jupiter missile battalion, Air Force personnel.[105]
1958, 1 May	WSPG renamed **White Sands Missile Range.**[106]
1958, 18 Jun	Army conducts **first** overland firing by combat troops of a large U.S. ballistic missile, the Redstone. Redstone also deployed to Europe with NATO shield forces, **first** operational U.S. ballistic missile.[107]
1958, 29 July	National Aeronautics Space Act creates **NASA**, responsible for **civil** space program.
1958, 15 Aug	**ARPA** authorizes ABMA to conduct research on 1.5 million lb **Juno** booster.
1958, Aug	Army delivers first Jupiter (missile #101) to Air Force for deployment overseas.[108]
1958, Oct	ARPA expands Army **Juno** V effort to study complete missile.

[101] Grimwood, p. 9-1.
[102] Akens, p. 1.
[103] Perry, p. 15.
[104] Perry, p. 15.
[105] Joiner, p. 76.
[106] Nimmen, p. 353.
[107] Bullard, pp. 119, 139, 169.
[108] Joiner, p. 118.

1958, 6 Dec	Army von Braun team launches the **first** successful **lunar probe**, Juno II (modified Jupiter C); it flies 63,580 miles toward moon.[109]
1958, 11 Dec	ARPA authorizes Army Ordnance Missile Command to begin design, modification, and construction of booster test and development facilities.[110]
1958, Dec	Army Redstone launch vehicle program is transferred to NASA at **Marshall Space Flight Center.**
1958, Dec	Press labels Redstone missile **"Old Reliable"** because it had only 2 failures in 41 launches during a 5-1/2–year period.[111]
1959, 8 Jan	NASA requests 8 Army Redstone Missiles for project Mercury.
1959, 3 Feb	Army Juno V program named **Saturn**, by ARPA.[112]
1959, 3 Mar	Army/JPL launch for NASA second lunar probe aboard a Juno II, which also became the **first** U.S. solar satellite.
1959, 21 Apr	DoD approves allocating two Pershing missile battalions per field army.[113]
1959, 26 May	Army conducts **first** successful booster firing of Saturn.[114]
1959, 27 July	Last Jupiter Missile frame completed at RSA.
1959, 18 Nov	Army transfers its 1.5 million lb thrust **Saturn** missile project to NASA, which assumes project technical direction.[115]
1960, 25 Feb	Army conducts first successful firing of Pershing missile.
1960, 14 Mar–1 July	ABMA **Development Operations Division** transferred to NASA, including von Braun team of 150 German scientists and engineers, 3900 ABMA personnel, and 2500 skilled missile and satellite technicians and craftsmen.
1960, Mar–Sept	AOMC realigns personnel, missions, and roles after transfer of ABMA Development Operations Division. ABMA assumes responsibility of long-range artillery missiles and anti-tank weapons, assigned Corporal, Sergeant, Honest John, Littlejohn, LAW, missile A, and liquid propellant missile B (Lance). **Army Rocket and Guided Missile Agency** assumes responsibility of air and space defense missiles and maneuverable missile systems, assigned Nike-Ajax, Nike Zeus, Nike-Hecules, HAWK, Redeye, Mauler, and Shillelagh.

[109] Grimwood, p. 13-2; Origins MSFC, p. 18; Stuhlinger, p. 66.
[110] Joiner, pp. 3–4.
[111] Baker and Nolan, p. 2.
[112] Joiner, p. 4.
[113] *Chronology of the ABMA*, p. 62.
[114] Joiner, p. 5.
[115] Joiner, p. 6.

1960, 26 May	Assembly of first Saturn booster stage begins at RSA.[116]
1960, 1 July	Army formally transfers Saturn to NASA.[117]
1960, 12 Aug	ABMA forwards to Chief of Ordnance revised plan for extended-range (400 miles) Pershing missile system.[118]
1960, 6 Oct	Office, Chief of Ordnance, requests AOMC conduct a design study for a medium-range ballistic missile (**MRBM**).[119]
1961–1973	U.S. Army fights war in **Vietnam.**
1961, May	**Improved Honest John,** nuclear-armed, solid-propellant, ballistic missile initially deployed.
1961, Nov	**Phase II Littlejohn,** nuclear-armed ballistic missile initially deployed.
1962, Sept	Sergeant, nuclear-armed, solid-propellant missile fielded as corps and Army support weapon.[120]
1962, June	Pershing first deployed in CONUS, 2-44th Missile Battalion.[121]
1964, Apr	Pershing first deployed in Europe, 4-41st Missile Battalion.[122]
1969, Sept	**Pershing 1a,** nuclear-armed ballistic missile initially deployed.
1973, June	**Lance,** nuclear-armed, liquid-propellant ballistic missile initially deployed.
1974, Mar	**Pershing II,** nuclear-armed ballistic missile R&D contract let.
1979, 30 Mar	**First** successful **MLRS** flight test, from 6-missile pack.[123]
1983, 31 Mar	First MLRS battalion deployed and IOC achieved.[124]
1983, Dec	Pershing II deployed.
1987, 8 Dec	U.S.-USSR sign the Intermediate-range Nuclear Forces (INF) treaty to reduce nuclear weapons in Europe and Russia.
1988, 1 Sept	U.S. begins withdrawal and destruction of European Pershing IRBMs per the INF treaty.

[116]Joiner, p. 10.
[117]Joiner, p. 12.
[118]*Chronology of the ABMA*, p. 94; "Missiles in Service," p. 19.
[119]*Chronology of the ABMA*, p. 97.
[120]"Missiles in Service," p. 20.
[121]Information provided by K. Hughes, MICOM Historical Office, 24 January 1989.
[122]Information provided by K. Hughes, MICOM Historical Office, 24 January 1989.
[123]Information provided by K. Hughes, MICOM Historical Office, 24 January 1989.
[124]Information provided by K. Hughes, MICOM Historical Office, 24 January 1989.

Appendix C
SATELLITE CHRONOLOGY

1907, 1 Aug	Aircraft enter military with establishment of Aeronautical Division, U.S. Army Signal Corps.
1908–1918	War Department makes Army Signal Corps responsible for development and operation of all military aircraft based upon the belief that aircraft would be used primarily for reconnaissance and message carrying.
1918	Army Air Service established.[125]
1918, 11 Nov	WWI Armistice signed.
1945, 3 Oct	Navy Bureau of Aeronautics produces first U.S. military satellite feasibility study and proposes development of an American satellite.[126]
1945, Nov	General of the Armies H. H. Arnold urges that the Army Air Forces start development of satellite space vehicles.
1946, 7 Mar	Navy proposes interservice space program.[127]
1946, 9 Apr	Joint Aeronautical R&D Board Committee (Navy and AAF) discusses proposal for an American satellite.
1946, 12 May	Army Air Forces receive the RAND study (SE 11827) "World-Circling Spaceship" proposing early development of an American satellite and attesting to the feasibility and general civil and military benefits of undertaking a five-year $150 million effort.[128]
1946, 14 Jun	Navy establishes Naval Ordnance Missile Test Center at Army WSPG.[129]
1947, 20 Feb	Army flies first Blossom Project V-2 missile for the Air Materiel Command, testing ejection of canister and recovery by parachute.[130]
1947, Jan	Navy asks Joint Aeronautical R&D Board Committee for authority over U.S. satellite development.
1947, Jun	Joint Aeronautical R&D Board Committee requests authority from DoD to fund satellite studies.[131]
1947, Fall	WSPG designs and proposes Army space flight experiment.

125"USAF Facts and Figures," p. 79.
126Perry, p. vi; Stares, p. 25.
127Perry, p. vii.
128Perry, pp. vii, 12–16.
129Perry, p. 6.
130Perry, p. 7.
131Perry, p. vii.

1947, 18 Sep	The U.S. **Air Force** officially created and activated.
1947, Dec	Navy claims satellite jurisdiction.[132]
1947, 19 Dec	Joint Aeronautical R&D Board Committee acquires DoD responsibility for coordination and control of Earth satellite vehicle programs.
1948, 15 Jan	GEN H. S. Vandenberg issues policy statement on primacy of **USAF space interest,** states that satellites are logical extension of strategic air power and initiates low-level USAF satellite R&D.
1948, 16 Jan	Navy withdraws claim for control of satellite development.[133]
1948, 26 July	Navy **Aerobee** rocket launched to altitude of 70 miles, carrying cameras that photograph the **earth's curvature.**[134]
1949, 3 Sept	A U.S. B29 weather reconnaissance aircraft detects radioactivity in Pacific indicating the first **Soviet nuclear explosion** occurred sometime between 26 and 29 August.
1950, 28 Jan	Army completes last of 52 WSPG V-2 firings, including **Albert monkey flights.**
1951, Apr	RAND publishes report R217 categorically stating the engineering feasibility of a military **reconnaissance satellite** using existing television technology to achieve general reconnaissance resolution of 100 feet and weather reconnaissance of 500-foot resolution.[135]
1951, 20 Sep	USAF makes first successful **live recovery** of animals (1 monkey and 11 mice) from a rocket flight to an altitude of 44.7 miles.[136]
1953, Oct–Dec	U.S. intelligence reveals Soviets well along in development of an **ICBM,** triggering a major shift in national security policy and a crash effort to develop an American ICBM.
1953, 3 Dec	**Weapon System 117L,** Advanced Reconnaissance (Satellite) System, is documented by USAF Air Research Development Command as first step in integrating proliferating satellite work into a single project and toward securing approval for a satellite program.[137]
1954, 1 Mar	RAND **Project Feedback** summary report published recommending USAF immediately develop imaging reconnaissance satellites as a matter of vital strategic interest.[138]

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[132] Perry, p. vii.
[133] Perry, p. vii.
[134] Perry, p. 8.
[135] Perry, pp. 31–33.
[136] Perry, p. 11.
[137] Perry, pp. vii, 35.
[138] Stares, p. 30.

1954, 1 Mar	Congress approves U.S. participation in International Geophysical Year (IGY) 1957–1958 program.
1954, Oct	USAF Asst Sec Gardner asks the Scientific Advisory Group to study and report on the interaction of current satellite proposals with the recently accelerated ICBM program.[139]
1954, Oct	Naval Research Lab Aerobee fired at WSPG takes first photographs of hurricane, achieves 100-mile altitude.[140]
1954, 27 Nov	System Requirement #5 issued, for developing a reconnaissance satellite.[141]
1955, 14 Feb	Technical Capability Panel (**Killian Committee**) recommends United States immediately develop advanced reconnaissance satellite capabilities and advanced high-altitude reconnaissance aircraft (U-2).
1955, 16 Mar	General Operational Requirement #80 is issued, covering development of a photographic reconnaissance satellite.[142]
1955, 26 May	**The National Security Council** rules that military rockets (Army **Redstone** and USAF **Atlas**) may not be used in the U.S. scientific/IGY satellite program (NSC 5520).
1955, 29 July	Eisenhower Administration announces U.S. intent to launch satellite in IGY 1957–1958.[143]
1956, 4 July	U.S. conducts first operational U-2 reconnaissance of USSR.[144]
1956, 24 July	USAF approves development plan for Weapon System 117L (reconnaissance satellite).[145]
1956, 19 Sept	Atomic Energy Commission (AEC) decides initial ICBM-IRBM nuclear warhead to be developed by **Los Alamos Scientific Laboratory.**[146]
1956, 8 Dec	First U.S.-IGY test rocket, a NRL **Viking**, attains an altitude of 126 miles, ejects a **minitrack radio** at 50 miles altitude.[147]
1954–1957	**Initial Army Satellite Efforts:**
**1954, 25 Jun	**ABMA/Dr. von Braun** presents Office of Naval Research proposal for using a Redstone main booster for joint launching of an earth satellite. Combined service

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139 Perry, p. viii.

140 Perry, p. 12.

141 Perry, p. viii.

142 Perry, p. viii.

143 *Staff Report of the Select Committee on Astronautics and Space Exploration*, 85th U.S. Congress, 2nd Session, U.S. Government Printing Office, Washington, D.C., 1959.

144 Burrows, p. 80.

145 Perry, p. viii.

146 *Chronology of the ABMA*, p. 8.

147 Perry, p. 14.

financing is needed to fund orbiting a satellite because single-service budgets are too small.

*1954, 15 Sept	Dr. von Braun publishes **first** true engineering thesis for a minimum satellite vehicle using existing Army Ordnance hardware. Thesis titled "A Minimum Satellite Vehicle."
**1955, 20 Jan	ABMA/von Braun proposal adopted as a joint Army-Navy venture titled **Project Orbiter.**[148]
**1955, Aug	Army-Navy Project Orbiter proposal is disapproved by the Assistant Secretary of Defense for R&D, who chooses the tri-service Navy-supervised **Vanguard** scientific (non-military) program to orbit the first U.S. satellite.
**1955, Late	Navy's Project Vanguard selected as priority U.S. satellite program. Navy's Vanguard team moves to Cape Canaveral during late 1955 and conducts two successful suborbital launches. [149]
**1955, Oct	Army receives DoD approval to conduct 12 IRBM nose cone reentry tests, opening door for Army to continue satellite-like launches.
**1956, 18 May	Special Assistant for Guided Missiles, SECDEF refuses Army request that ABMA's Jupiter-C be a **backup alternate to Vanguard.**
*1956, 20 Sept	**Jupiter-C missile #RS-27** launches nose cone to 682-mile altitude during Army nose cone reentry tests.
**1957, 25 Apr	The ABMA-prepared **JANUS** report indicates that a reconnaissance satellite is technically feasible.[150]
**1957, July	Because of rumors that the Army is engaged in an unauthorized satellite program, SECDEF orders the Dept. of Army to refrain from any satellite orbiting activity.[151]
**1957, 8 Aug	After successful Jupiter flight #RS-40, Army recovers **first** object (scale model, fiberglass and resin nose cone) retrieved from space, Jupiter **nose cone ablation** principle verified by Army flight tests, principle later used in reconnaissance satellite payload recovery capsules and the manned space program.
**1957, 4 Oct	SECDEF McElroy briefed at RSA by Commanding General Medaris, ABMA, on how soon Army can launch a satellite.

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[148] Satterfield, p. 53.

[149] "Apollo and Beyond," 20th Special Edition, *Gazette Telegraph*, Colorado Springs, CO, 16 July 1989, p. 3.

[150] *Chronology of the ABMA*, p. 18.

[151] Bullard, p. 143.

1957, 4 Oct	USSR launches first earth orbiting satellite, 184 lb **Sputnik 1.**
1957, 3 Nov	USSR launches 1120 lb **Sputnik 2.**
1957, 7 Nov	President Eisenhower announces United States has solved missile reentry problem, shows on TV the nose cone recovered from Army Jupiter C flown 8 Aug 1957. [152]
1957, 8 Nov	After six Vanguard failures, the **SECDEF** directs Army to attempt to orbit a U.S. satellite by March 1958.
1957, 6 Dec	Navy Vanguard missile explodes on launch pad.
1957, 24 Dec	ABMA briefs Mr. A. Dulles, Chief of **CIA**, on Army capability to orbit 20, 100, and 500 lb satellites for intelligence, communication, meteorological, mapping, and geodesy missions.[153]
1958–1959	Army conducts **Explorer Satellite Program:**
**1958, 31 Jan	ABMA/JPL launches **Explorer I** aboard an Army Jupiter-C missile, **first** free world earth-orbiting satellite; it measures high-altitude radiation belts and demonstrates bearable temperatures for humans within satellites.
**1958, 5 Mar	Army-launched **Explorer II** fails to orbit.
**1958, 26 Mar	ABMA launches **Explorer III** aboard a Juno I (modified Jupiter-C), **first** U.S. earth satellite to store information on tape and play it back when interrogated from ground.[154]
**1958, 26 July	ABMA launches **Explorer IV**, satellite used to measure high-altitude **Project Argus** nuclear explosion effects and take sun measurements.[155]
**1958, 24 Aug	Army-launched **Explorer V** fails to orbit.
**1958, 23 Oct	Army-launched **Explorer VI** fails to orbit.[156]
**1958, Dec	Army Explorer satellite program and Redstone launch vehicle program are transferred to NASA at Marshall Space Flight Center.
**1959, 13 Oct	ABMA launches **Explorer VII**, scientific earth satellite for NASA.[157]
1958–1959	Army supports tri-service **Vanguard Satellite Program:**
**1958, 17 Mar	Army Signal Corps designs and builds **Vanguard I** cloud cover satellite **solar converters** for NASA. **First** successful space flight test proving solar converter feasibility.

[152] *Chronology of the ABMA*, p. 27.
[153] *Chronology of the ABMA*, p. 31.
[154] Medaris, Significant Achievements; Origins MSFC, p. 16.
[155] Stuhlinger, p. 66.
[156] Origins MSFC, p. 16; Bullard pp. 145–146.
[157] Joiner, p. 122.

**1959, 17 Feb	Army Signal R&D lab develops for NASA the complete electronic satellite package for **Vanguard II**, conducts infrared cloud mapping from space.
**1959, 18 Sep	**Vanguard III** marks end of Vanguard launches.[158]
1958, Feb	President Eisenhower directs CIA to develop reconnaissance satellites separate from USAF, resulting in **Project Corona.**
1958, 27 Mar	SECDEF assigns ABMA to launch two **lunar probes** using Jupiter missiles.
1958, 20 June	**NSC directive 5814/1,** U.S. Policy on Outer Space, published recognizing national security threat to United States of Soviet space achievements and the national security utility and necessity to immediately develop a reconnaissance satellite.
1958, July–Nov	ABMA proposes and receives approval from the Dept. of Army to conduct a **Television Feasibility Demonstration Project** to show the feasibility of TV battlefield reconnaissance. Proposal origins were the Janus B studies.
1958, 29 July	National Aeronautics Space Act creates **NASA**, responsible for **civil** space program.
1958, 6 Dec	ABMA/JPL launch **first** successful lunar probe, **Pioneer III,** for NASA aboard a modified Jupiter-C/Juno II missile, travels 63,580 miles toward moon.
1958, 13 Dec	Army launches **first** space flight of a live primate on ballistic missile and conducts other biomedical, biophysical space flight tests in conjunction with Florida State University.[159]
1958 18–19 Dec	Army Signal Corps develops communication payload of the **first** military satellite successfully orbited, Signal Communication by Orbital Relay Equipment (**SCORES**); Army conducts effort for ARPA. This was the **first** voice communication from space; President Eisenhower sends his Christmas message to the world via SCORES.
1959, 8 Jan	NASA requests eight Army Redstone-type missiles to be used to support **Project Mercury** (manned satellite).
1959, Jan	NASA **astronaut** selection criteria publicly released; candidates must be test pilot school graduates.
1959, 3 Mar	Army/JPL launch **Pioneer IV** aboard Juno II, second lunar probe Army conducted for NASA and **first** U.S. satellite to orbit the sun.

[158] Origins MSFC, p. 19.

[159] Medaris, Significant Achievements; Origins MSFC, p. 18; Stuhlinger, p. 66.

1959, Apr	Joint Meteorological Satellite Advisory committee established.[160]
1959, Apr–June	ABMA develops **Project HORIZON** feasibility study/blueprint for landing men on moon and establishing a lunar outpost by the mid-1960s. The study is submitted to Army Chief of Staff General Taylor and transmitted to NASA.[161]
1959, 28 May	Army conducts **first** successful flight and live recovery of animal passengers from flight into space (**monkeys Able and Baker**), paving the way for putting the first U.S. man in space.
1959, 12 Sept	Soviet **Luna 2** satellite hits the moon.[162]
1959, 13 Nov	Army begins TV reconnaissance flight tests.
1959, 18 Nov	Army transfers its 1.5 million lb thrust **Saturn** space booster project to NASA, which assumes project technical direction.
1960, 29 Feb	ARPA establishes the **ADVENT** program as a single 24-hour, equatorial synchronous, military communication system. Army is to develop satellite/communication equipment and USAF to handle booster and spacecraft.
1960, 15 Mar	Army launches **first** flying **TV** station aboard a Redstone missile.
1960, 1 Apr	Army Signal Corps develops for NASA the **TIROS I** (Television and Infrared Observation Satellite), producing the **first** satellite **television signals** from space, launched on USAF Thor-Able.
1960, 12 Aug	The first passive relay communication satellite, **Echo I**, successfully launched into orbit, demonstrating feasibility of global communication via satellites.[163]
1960, 26 Sept	ABMA receives tentative military characteristics outline from Chief of Ordnance for a **meteorological** rocket.[164]
1960, 4 Oct	Army Communication satellite **COURIER I B** is launched; it stores and then transmits messages on command, establishing the feasibility of satellite relay of all types of facsimile messages.[165]
1960, 23 Nov	Army Signal Corps develops for NASA **TIROS II** weather satellite sensors.
1960, Fall	U.S. reconnaissance satellites begin returning crude intelligence on Soviet Union.[166]

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[160] Perry, p. 19.

[161] T. Ordway, S. Sharp, and C. Wakefore, *Project HORIZON, an Early Study of a Lunar Outpost*, paper presented at 21st Symposium on History of Astronautics, Brighton, England, 16 October 1987.

[162] Burrows, p. 99.

[163] Perry, p. 21.

[164] *Chronology of the ABMA*, p. 96.

[165] *A History of the Signal Corps*, p. 16.

[166] Stares, p. 62.

1961, 31 Jan	First successful orbiting of USAF Satellite and Missile Observation System (**SAMOS**), television reconnaissance satellite (previously named WS 117L).[167]
1961, 6–28 Mar	**DoD Directive 5160.32,** Development of Space Systems, coordinates DoD satellite development by assigning the following responsibilities: >>Each service can conduct preliminary research to use satellite technology. >>Army to continue **ADVENT** communication satellite work. >>Navy to continue **TRANSIT** navigation satellite work. >>Air Force to perform satellite advanced R&D and operate all DoD reconnaissance satellites except **CIA/NSA** reconnaissance satellites. >>DoD to review and approve all advanced satellite R&D proposals.
1961, 12 Apr	USSR launches and orbits first man in space, Yuri Gagarin.[168]
1961, 5 May	Modified Army Redstone rocket carries **first** American, **Alan B. Shepard,** into space on a suborbital flight.
1961, 25 May	**Kennedy** Administration announces national decision to land an American on the moon.
1961, 21 July	Modified Army Redstone rocket carries **Virgil I. Grissom** into space.[169]
1961–1973	U.S. Army fights war in **Vietnam.**
1962, 23 May	SECDEF McNamara cancels the ADVENT satellite program because of delays in the USAF Centaur upper stage and management difficulties.
1964, Oct	NASA modifies astronaut selection criteria, dropping the jet pilot experience requirement and allowing scientist-astronauts.[170] New criteria allow Army personnel to qualify for astronaut duty.
1965, 2 Oct	Deputy SECDEF establishes DoD Tactical Satellite Communication Program (**TACSATCOMP**). Army assigned principal responsibility for ground terminals and land vehicles. Space segment assigned to another service; planning operational use assigned to Joint Chiefs of Staff.[171]
1967	U.S.-USSR sign the **Outer Space Treaty** banning nuclear and other mass destruction weapons from earth orbit or upon celestial bodies.
1969, 16–20 Jul	Apollo 11 launched; United States lands first men on moon.[172]

[167] Burrows, pp. 90–91.
[168] Nimmen, p. 4.
[169] Nimmen, p. 380.
[170] NASA JSC Education Brief #10013, Houston, TX, 1966, p. 5.
[171] TACSATCOMP, p. 1-1.
[172] "Apollo and Beyond," pp. 3–8.

1972, 5 Jan	President Nixon approves NASA development of the Space Transport System (**space shuttle**), able to carry military payloads and observers.[173]
1972, 26 May–3 Oct	U.S.-USSR sign the Anti-Ballistic Missile (**ABM**) Treaty limiting each country to one 100-missile ABM site and sign the Interim Agreement on a Strategic Arms Limitation Treaty (**SALT**), where both parties agree not to interfere with national technical means (**NTM**) of verification.
1977	Congress directs services to form **TENCAP** offices.
1977–1978	NASA authorizes **science and mission specialists** to fly on shuttle, further opening door for Army manned space flight participation.
1979, Aug	**First** Army astronaut/mission specialist chosen, **MAJ R. L. Stewart** (later Brigadier General).
1981, 12 Apr	First Space Transport System (shuttle) launched.[174]
1984, 3–11 Feb	**First soldier in space,** LTC R. L. Stewart, conducts space walk during shuttle mission 41B.
1987, 5 Jan	U.S. **Army** Space Command **NASA Detachment** established at JSFC.
1987	Army presents concept and requests permission from the DoD Military-Man-in-Space Prioritization Board to conduct **Terra Scout** and **Terra Geode** observation missions from space shuttle.
1987	DoD/JCS **MILSATCOM C2** concept approved, assigns DSCS from USAISC to **Army Space Agency.**
1987	During Reforger 87 Army conducts a tactical weather **satellite demonstration.**
1988, FY	By 2 Nov 88, Army provides $5 million to DARPA to perform **lightsat** R&D.

[173] Stares, p. 161.
[174] "Apollo and Beyond," p. 3.

Appendix D

GROUND STATION, RADAR, AND COMMUNICATION CHRONOLOGY

1937, May	COL W. Blair, Director of the Army Signal Corps laboratories, Ft. Monmouth, patents the **first** Army/military **radar**.
1941–1945	**Army Signal Corps WWII** accomplishments: >>Virtually all the important radar equipment employed by the United States in combat up to the end of WWII, including the SCR-268 anti-aircraft radar, SCR 270 mobile long-range early warning radar, and the complete radar equipment of the B-29s, is developed under the Signal Corps program. >>Signal Corps developed, produced, and fielded major advances in multichannel signal/communication wire, cable, radio synchronization, and automatic encryption. >>By 1945, the **Signal Corps Army Communication Service** operates worldwide communication ground stations, greatest unified military communication system developed to date, composed of Army Communication and Administration System (ACANS) and Army Airways Communication System (AACS).
1944	Army establishes White Sands Proving Grounds (**WSPG**).
1946, 10 May	**Army Signal Corps** successfully conducts **Project Diana. First** beaming of radar signals off the moon to study the propagation of signals in space; marks the beginning of space communications.[175]
1950, Dec	Construction starts at Grand Bahama Island for the first tracking station on the Florida Missile Test Range, later renamed Atlantic Missile Range (**AMR**).[176]
1957, Aug	U.S. and Canada ratify the bi-national agreement forming the North American Air Defense Command (**NORAD**).
1958, 14 Jan	Army Signal Corps bounces signals off moon to calibrate the prime satellite tracking stations of the **IGY minitrack network** it operated, using the **Space Sentry** radio transmitter.[177]
1958, 26 Mar	ABMA launches **Explorer III** aboard a Juno I (modified Jupiter-C), **first** U.S. earth satellite to store **information on tape** and play it back when **interrogated from ground.**

[175] *A History of the Signal Corps*, p. 32.
[176] Perry, p. 10.
[177] *A History of the Signal Corps*, p. 14.

1958 **ARPA** begins developing an integrated satellite tracking network by combining Army, Navy, and USAF tracking assets, **Project Shepard.**[178]

1960, 4 Apr Army Corps of Engineers (COE) and NASA agree Army will design, contract, supervise construction of, and inspect the majority of NASA facilities at MSFC, Kennedy Space Center, and Mississippi Test Facility.[179]

1960, 1 Aug Army announces completion of radar mapping of lunar landing sites.[180]

1960, 4 Oct Army Communication satellite **COURIER IB** is launched; it stores and then transmits messages on command. **First** space flight test establishing the feasibility of satellite relay of all types of **facsimile messages.**

1960 Defense Communication Agency (**DCA**) established to improve and regulate strategic armed forces long-distance communications.

1961 Army ground station teams begin operating fixed **satellite terminal stations** at Ft. Dix and Camp Roberts.

1961–1973 U.S. Army fights war in **Vietnam.**

1964, 1 Mar Army establishes Strategic Communication Command (**STRATCOM**) to operate Army portion of global Defense Communications System (**DCS**) and act as the single Army manager of strategic/long-haul communication in support of:

>>Five major sub-areas (CONUS, Alaska, Europe including Africa and Mideast, Central and South America, and SE Asia) with sub-area units including operation and maintenance of ground satellite communication facilities.

>>NCA with the Joint Support Command.

>>U.S. Air Defense Command with the STRATCOM Air Defense Signal Group.

>>Civil Defense Communication.

>>Non-defense national communication.[181]

1964, Apr–Aug STRATCOM establishes long-haul voice and telephone DoD satellite communication ground stations using **SYNCOM** constellation, for transmissions between Vietnam, CINCPAC, and United States. This is the **first** synchronous satellite communication network:

>>2 Apr AN/MSC-44 at Clark AFB, Philippines.

>>July Five-van station at Oahu, Hawaii.

>>Aug Mark IV (X) and (I) models at Saigon, Vietnam.

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[178] Stares, p. 131.

[179] Boone, p. 21.

[180] *Chronology of the ABMA*, p. 94.

[181] *A History of the Signal Corps*, p. 17.

1964, Fall	STRATCOM establishes satellite ground stations at Korat, Thailand, and Decomere-Guru, Ethiopia.
1965, Jan	DCA requests Army enlarge STRATCOM ground station crews in order to maintain 24-hour SYNCOM communications.[182]
1965	STRATCOM supports joint DoD/DCA planning of the Initial Defense Communication Satellite Project (**IDCSP**) replacement to SYNCOM.
1965	Army Satellite Communication Agency (**SATCOMA**) conducts R&D of **first** generation UHF, Experimental Army Satellite Tactical Terminals (**EASTT**) employing small parabolic field antennas.
1965, 2 Oct	Deputy SECDEF establishes DoD Tactical Satellite Communication Program (**TACSATCOMP**). Army assigned principal responsibility for ground terminals and land vehicles. Space segment assigned to another service; planning operational use assigned to Joint Chiefs of Staff.
1966	STRATCOM assumes operational control of SYNCOM for DCA and begins operations with IDCSP.[183]
1966, Jan	DCA approves STRATCOM Okinawa SYNCOM ground station.[184]
1966, June	STRATCOM IDCSP MSC-46 ground station at Laudstuhl, Germany, becomes operational.
1966, 16–30 Jun	Air Force launches 7 satellite IDCS constellation; IDCS becomes operational with STRATCOM's Army Satellite Communication Agency-developed primary (Ft. Dix and Camp Roberts) and mobile AN/MSC-46 ground stations.[185]
1967	Army operates all DCA/DoD SYNCOM and IDSC ground stations: >>Spring 67, Germany and Ethiopia ground stations provide 98% availability during Israel-Arab Mideast crisis. >>1 July 67, transfers operational control of IDCS ground station Philippines to the Air Force and ground station Hawaii to the Navy. >>Fall 67, IDCS 17 relay satellite constellation provides 90% global coverage.[186]
1967, FY	Phase I of the Defense Satellite Communication System (**DSCS**), the follow-on to IDSC, is in full use; STRATCOM operates a ground station at Yong San, Korea.[187]

182Rolack, p. 148.

183Rolack, p. 148.

184Rolack, p. 150.

185*Army R&D Newsmagazine*, "Launching of 8 Satellites Heralds Era of Global Communications for Defense," July–August 1966, p. 10; Rolack, p. 151.

186Rolack, p. 153.

187Rolack, p. 155.

1969	**NORAD** controls and operates global Space Detection and Tracking System (**SPADATS**) composed of: Space Track phased-array radars, Eastern and Pacific Missile Test Range radars, 440L Over the Horizon radars, Smithsonian Astrophysics Observatory cameras, USAF-operated Baker-Nunn cameras, NASA Tracking and Worldwide Satellite Observation Network, and Sunnyvale Space Control Facility.[188]
1970, 27 May	Deputy SECDEF directs Phase II DSCS implementation; Army to determine ground station development improvements and replacements to handle multiple access and digital signals.[189]
1970, 8 Sept	**Revised DoD Directive 5160.32,** Development of Space Systems, assigns the following DoD satellite development responsibilities: >>Each service can conduct research and receive approval to develop the following type satellites: **"unique"** battlefield and ocean surveillance, communication, navigation, meteorological, mapping, charting, and geodesy. >>Air Force to perform R&D, production, and deployment of the following systems: launch support, launch vehicles, warning and surveillance satellites of enemy nuclear delivery capabilities, and **orbital support operations.** >>DoD Director of Defense R&D to serve as focal point for space technology and systems to prevent unwarranted duplication, minimize technical risk and cost, and ensure **multiple service needs are met.**
1970, Post	SPADATS additions during the 1970s are: >>Army Cobra Dane phased-array radar at Shemya Island. >>Army Safeguard Perimeter Acquisition Radar (PAR). >>Pave Paws SLBM phased-array radar Otis and Beale AFB. >>Ground-based Electro-Optical Deep Space Surveillance. >>Satellite-borne LWIR sensors.[190]
1971, 5 Aug	Army publishes *Ground Mobile Forces Tactical Satellite Communication Development Concept Paper.*[191]
1975	**NORAD** assigned aerospace attack early warning and surveillance mission.
1979, 1 Oct	NORAD Space Defense Operations Center (**SPADOC**) goes operational at Cheyenne Mountain, Colorado.[192]

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188 Stares, pp. 132–133.
189 Rolack, p. 160.
190 Stares, p. 206.
191 TACSATCOMP, p. 83.
192 Stares, p. 212.

1982, 21 Jun	USAF Chief of Staff announces formation of **USAF Space Command** in Colorado Springs, Colorado.[193]
1983, 1 Oct	**Naval Space Command** established at Dahlgren, Virginia.[194]
1985, Sept	SECDEF establishes **UNIFIED SPACE COMMAND.**
1987	DoD/JCS **MILSATCOM Command and Control** concept approved, assigns DSCS from USAISC to **Army Space Agency.**
1988, 7 Apr	**Army Space Command** established within USSPACECOM.

[193] Stares, p. 220.
[194] Stares, p. 220.

Appendix E

ANTI-AIRCRAFT/MISSILE/RV AND ASAT CHRONOLOGY

1937, May	COL W. Blair, Director of the Army Signal Corps laboratories, Ft. Monmouth, patents the **first Army radar.**
1941, 7 Dec	Army SCR-270 early warning radar detects approach of Japanese aircraft toward **Pearl Harbor.**[195]
1941–1945	**Army Signal Corps WWII** accomplishments: >>Virtually all the important radar equipment employed by the United States in combat up to the end of WWII, including the SCR-268 anti-aircraft radar, SCR 270 mobile long-range early-warning radar, and the complete radar equipment of the B-29s, is developed under the Signal Corps program.[196]
1944, Feb	Army Ordnance and AAF initiate development of surface-to-air, high-altitude, supersonic guided missile, later to become XSAM-A-7 **Nike I.**
1944, 20 Nov	Army lets **Hermes** missile contract to General Electric to study how to best meet the needs of the Army Field Forces with long-range artillery missiles and high-altitude **anti-aircraft missiles.**
1945, Feb	Army Ordnance Department initiates **Project Nike**, lets Nike **Ajax** missile contract and feasibility study of a guided missile **anti-aircraft defense** to **Bell Labs.** RSA assigned responsibility for R&D supervision and coordination.
1946, 26 Sept	First test firing of experimental Nike R&D booster, at WSPG.
1946	Army activates the Air Defense Command (**ADC**) to perform continental U.S. air defense.
1947, Dec	Dept of Army approves RSA development of an anti-aircraft free-flight rocket weapon, called **LOKI.**[197]
1948	SECDEF J. V. Forrestal completes negotiations with the military services on **missions and roles**: Army responsible for land operations, **continental anti-aircraft defense**, and overseas occupation and security forces.
1949, 3 Sept the	A U.S. B-29 weather reconnaissance aircraft detects radioactivity in Pacific, indicating first **Soviet nuclear explosion** occurred sometime between 26 and 29 August.

[195]*Concise History U.S. Army Signal Corps*, pp. 21–22.
[196]*Concise History U.S. Army Signal Corps*, pp. 21–22.
[197]Joiner, p. 34.

1951, 16 Aug	Chief of Ordnance assigns RSA R&D responsibility for the **Nike Program.**[198]
1951, 27 Nov	A Nike Ajax missile makes **first** successful U.S. intercept of an aircraft flying at 300 mph at 33,000 ft altitude at a range of 15 miles.
1952, 20 Feb– 25 Jun	**JPL** performs study for Army on feasibility of the **Corporal** becoming an anti-aircraft missile.[199]
1952, May	Ordnance Department initiates feasibility study of an improved Nike Ajax, titled **Nike Hercules**, extending **air defense up to 100 miles altitude.** RSA assigned technical responsibility.
1952, May–Oct	Ordnance Department formally establishes long-range military requirements for **PLATO,** a guided **anti-missile missile**, and initiates contract study of methods to counter ballistic missile attack of ground forces.[200]
1953, Oct–Dec	U.S. intelligence reveals Soviets well along in development of an **ICBM,** triggering a major shift in national security policy and a crash effort to develop an American ICBM.
1953, Dec	Army Anti-Aircraft Command's **Nike Ajax** becomes operational. **First** operational anti-aircraft missile unit.
1954, 20 Mar	**First** Army Nike Ajax, continental defense, anti-aircraft battalion deployed at Ft. Meade, Maryland, to protect the Washington-Baltimore area.
1954	Joint Chiefs of Staff establish USAF Continental Air Defense Command (**CONAD**) as a unified command with ADC as a component.
1957, 27 Aug	USSR launches first successful ICBM.
1957, 4 Oct	USSR launches first earth-orbiting satellite, **Sputnik 1.**
1957, 3 Nov	USSR launches second earth-orbiting satellite, **Sputnik II**, weighing 1120 lb, clearly showing USSR capability to deliver ICBM-delivered nuclear warheads.
1955–1963	Army conducts Nike Hercules and **Nike Zeus** R&D:
**1955, Mar	Army initiates **Nike II study** with Bell Labs to determine common air defense system against all future (1960–1970s) high-altitude bomber and **ICBM** threats. Contract is modified on 15 Nov to perform anti-ICBM (**AICBM**) for USAF.[201]
**1956, 26 Nov	SECDEF issues **military service missions and roles** statement fixing Army responsibility for "**point defense.**"

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[198] Joiner, p. 41.

[199] Corporal Monograph #4, p. xvii.

[200] Joiner, pp. 45–46.

[201] Project History, pp. I-1 through I-6.

**1957, 15 Feb Ordnance Department directs RSA and Bell Labs/Western Electric Co. to develop Nike Zeus anti-ICBM system based upon improved nuclear-tipped solid-propellant Nike Hercules missile and long- and short-range radars.

**1957, 3 Oct Anti-Missile Missile System office activated at RSA.

**1958, 28 June Nike Hercules deployed in continental United States at Washington, D.C.; New York City; and Chicago.

1958, 26 July ABMA launches **Explorer IV, satellite used to measure high-altitude **Project Argus** nuclear explosion effects.

**1958, 15 Sep Nike Hercules deployed on Formosa.

1958, 19 Nov A Nike Hercules makes **first successful intercept of a high-altitude supersonic target missile traveling faster than 1500 mph above 60,000 ft.

1959, 12 Feb DoD approves Army Nike Zeus test program, use of **Kwajalein Island, and Jupiter IRBM targets. Plan modified by DoD one year later to shoot at **Atlas** missiles launched from Vandenberg.

**1959, Aug First successful flight test of the anti-missile missile Nike Zeus, at WSMR, New Mexico.[202]

**1959, 9 Nov Army justifies to DoD Johnston Island facilities for Nike Zeus program.[203]

**1959, 15 Dec Army-Navy MOU for Nike Zeus testing at Kwajalein-Johnston Island forwarded by Army Adjutant General.

**1959 Army begins construction of Nike Zeus facilities at Kwajalein Atoll, Pacific Ocean.[204]

1960, Mar–Sept **AOMC realigns personnel, missions, and roles after transfer of ABMA Development Operations Division. **Army Rocket and Guided Missile Agency** assumes responsibility of air and space defense missiles and maneuverable missile systems, assigned Nike Ajax, Nike Zeus, Nike-Hecules, HAWK, Redeye, Mauler, and Shillelagh.

1960, 3 Jun A Nike Hercules makes **first intercept of a **ballistic missile** (Corporal) by another missile at WSMR.

1961, 28 May Nike Zeus Target Tracking Radar (TTR**) successfully tracks an ICBM launched at the AMR.

1961, Jun Army authorizes Bell Labs to initiate studies of **electronically steered radars and proceed with design of a prototype **phased-array radar.**

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[202] Holm, p. 55.
[203] *Chronology of the ABMA*, p. 74.
[204] Kwajalein, p. 31.

**1961, 14 Dec	First full system demonstration of Nike Zeus, including successful intercept of a Nike-Hercules by a Nike Zeus.[205]
**1962, 19 July	Nike Zeus makes **first** U.S. successful (within nuclear kill distance) intercept of an **ICBM.** Ten additional test intercepts flown through November 1963.
**1963, 1 Feb	Nike Zeus Project becomes a **class II DoD activity** but remains attached to MICOM.[206]
1957–1963	Initial **Army ASAT capability** developed:
**1957, 22 Mar	SECDEF chooses Redstone missile for launching high-altitude, nuclear detonations for the Atomic Energy Commission (AEC) during **Operation Hardtack.**
**1957, 19 Nov	Army publishes its space program recommendation that a national security requirement exists for an anti-satellite (**ASAT**) system and proposes to DoD that a modified 3-stage, Nike Zeus be used as an ASAT weapon.
**1958, 31 July	Redstone Missile #50 fired from Johnston Island, lofting an Operation Hardtack nuclear warhead and detonating it at a 47.5-mile/76-km altitude.
**1961, 6 May	Army Nike Zeus Target Tracking Radar (**TTR**) successfully tracks the Echo satellite at a distance of 1400 miles.
**1962, May	SECDEF McNamara instructs Army to develop nuclear-tipped, modified Nike Zeus ASAT defense system, code named **Mudflap**/Project 505.
**1962, 17 Dec	**First** successful Army ground-launched ASAT attack against a simulated satellite target (a point in space at 100 miles altitude over WSMR) by a DB-15B series Zeus missile.
**1963, 24 May	**First** successful Army ground-launched satellite intercept against an actual satellite, with Mudflap missile #5.
**1963, 1 Aug	Army deploys Mudflap **ASAT defense** system in Pacific on Kwajalein Atoll.
1958, Feb	**NSC directive 5802/1,** U.S. Policy on **Continental Defense,** is published, recognizing need for continental defense system and importance of satellite defense and need for vigorous R&D in these areas.
1958, Sept	ARPA **Project Argus** conducted, exploding nuclear device in space at 125- and 300-mile altitudes.[207]

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[205] Project History, p. I-24.

[206] Army Materiel Command General Order #11, 11 and 13 February 1963.

[207] Stares, pp. 107–108.

1959, 13 Oct	USAF conducts world's first ASAT intercept with **Bold Orion Missile #12** air-launched from flying B-47.[208]
1960–1970	Army conducts Reentry Measurements Program (**RMP**) to establish radar characteristics of nuclear reentry warheads.[209]
1960, 21 July	DoD approves USAF to use its own funds to initiate **Project Saint** as a satellite inspection vehicle using TV and radar sensors; USAF cancels effort 3 Dec 1962; no flight tests conducted.[210]
1962, Apr–July	Navy conducts **Project HiHo**, two missile launches from flying phantom F4D, second missile reaches an altitude of 1000 miles.[211]
1962, 9 July	**Fishbowl** series of upper atmosphere/space nuclear explosions reveals collateral damage effect on friendly satellites.[212]
1962, Oct	**Cuban Missile Crisis:** HAWK and Nike units repositioned into SE United States to augment local air defense.[213]
1962, Dec	SECDEF McNamara gives USAF permission to test Thor IRBM as an ASAT weapon; **Program 437** first flight test not until December 1964.[214]
1963, May	**Sam-D** (renamed **PATRIOT** in 1976) anti-aircraft missile feasibility study initiated.
1963, 10 Oct	U.S. Congress ratifies U.S.-USSR **Limited Test Ban Treaty** prohibiting nuclear explosions in outer space.
1963, FY	ARPA conducts **non-nuclear ASAT** feasibility studies.[215]
1966–1968	Soviet Union begins testing **co-orbital ASAT** interceptor components and system. On 20 Oct 1968, Cosmos 249 explodes after flying past Cosmos 248.[216]
1963–1968	Army develops **Nike-X/Sentinel** system:
**1963, 3–5 Jan	SECDEF R. L. Gilpatrick directs the priority development of an ABM defense system and for the Army to reorient the Nike Zeus effort toward a new system approach that could handle high-traffic Soviet ICBM attack employing chaff and decoys.
**1964, 1 Feb	Nike Zeus Project renamed **Nike-X.**

[208] Stares, p. 109, Table 1.
[209] Project History, p. 2-15.
[210] Stares, pp. 114, 116.
[211] Stares, p. 111.
[212] Stares, pp. 76–81.
[213] Matloff, p. 595.
[214] Stares, p. 80.
[215] Stares, p. 128.
[216] Stares, pp. 135–137.

**1964, June	Army's **first** electronically steered phased-array radar becomes operational at White Sands Missile Range, New Mexico.
**1964	Navy transfers Kwajalein Test Site to U.S. Army, which renames it **Kwajalein Missile Range** (KMR).[217]
**1966	LTG A. W. Betts, Army Chief of R&D, is given direct responsibility for the Nike-X program and reports directly to the Army Chief of Staff.[218]
**1967, 18 Mar	Johnson Administration initiates continental defense, nuclear, anti-ballistic missile Sentinel Defense Program (previously Nike-X) with 2-stage, solid-propellant, point defense **endoatmospheric Sprint** missile and barrage-fired **exoatmospheric** 3-stage, solid-propellant, area defense **Spartan** missile (previously Zeus DM 15X2).
**1967, Sep	SECDEF McNamara announces the U.S. decision to **deploy** the Sentinel BMD system to protect urban-industrial areas from Chinese ICBM attack, as a defense against an accidental launch, and with the option to defend **Minuteman** missile sites.[219]
**1967, 15 Nov	Sentinel system established under Army Chief of Staff with two subordinate class II DoD activities: Sentinel System Command (**SENSCOM**) and the **Sentinel System Evaluation Agency** at WSMR. SENSCOM takes over the Nike-X project from AMC.
**1967	DoD Dir of Def R&E directs SENSCOM to focus on developing the Sentinel system and not advanced ABM research.[220]
**1967	Army Ballistic Missile Defense Research Office established to conduct Advanced BMD technology R&D. Renamed Advanced Ballistic Missile Defense Agency (**ABMDA**) in 1968.
**1968, 30 Jun	Army Advanced Ballistic Missile Defense Agency established as a class II DoD activity; SENSCOM Nike-X advanced research and MICOM Project Defender work assigned to ABMDA.
1969–1976	Army develops **Safeguard ABM system:**
**1969, 14 Mar	Nixon Administration reorients Sentinel effort, renaming it **Safeguard** and employing long-range Spartan and short-range Sprint solid-propellant missiles to primarily defend land-based U.S. ICBMs. Safeguard System Command (**SAFSCOM**) is established.

217 Currie-McDaniel, p. 7.
218 Currie-McDaniel, p. 6.
219 Currie-McDaniel, p. 7; Project History, p. I-45
220 Currie-McDaniel, p. 8.

**1970, Apr	Army SAFSCOM authorizes development of the BMD Center (**BMDC**), to be co-located with NORAD within Cheyenne Mountain.[221]
**1970, 23 Dec	Army Sprint missile makes its **first** successful ICBM intercept, mission M1-12 at Kwajalein.
**1971, 11 Jan	**First** successful Spartan salvo launch and intercept of a reentry vehicle, mission M1-30 at Kwajalein.
**1971, Feb	Army initiates Minuteman **Hardsite Defense** project (later called site defense). Original feasibility studies were initiated in December 1966 to identify needed ABM defense for hardened U.S. silos.[222]
**1972, 26 May–3 Oct	United States and USSR sign the Anti-Ballistic Missile (**ABM**) Treaty limiting each country to one 100-missile ABM site and sign the Interim Agreement on a Strategic Arms Limitation Treaty (**SALT**), where both parties agree not to interfere with national technical means (**NTM**) of verification.
**1974, 20 May	Ballistic Missile Defense Organization (**BMDO**) established by consolidating SAFSCOM and ABMDA ABM deployment/operations and advanced research activities. SAFSCOM redesignated Ballistic Missile Defense System Command (**BMDSCOM**). ABMDA redesignated Ballistic Missile Defense Advanced Technology Center (**BMDATC**).
**1974, 3 July	Protocol-modified Article III of the ABM treaty signed in Moscow. Modification to go into effect on 24 May 1976.
**1975	Kwajalein Army ASAT system deactivated.
**1975, Apr–Oct	Army **activates** Safeguard ABM system, IOC April 1975. FOC 1 Oct 1975. **First** U.S.-deployed continental ABM defense system.
**1976, Feb	Army initiates Safeguard ABM system **deactivation.**
**1977, Oct	Army transfers Safeguard **Perimeter Acquisition Radar** to USAF for incorporation in strategic early warning network.[223]
1975, 27 Feb	First successful PATRIOT flight test.
1975, Nov	Several U.S. satellites blinded by unidentified light source in Soviet Union.
1976, 16 Feb	Soviets resume co-orbital ASAT testing with Cosmos 803.
1977, 18 Jan	President Ford signs **NSDM-345** committing United States to development of an operational ASAT capability.

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[221] Project History, pp. 4-1 and 12-1.
[222] Currie-McDaniel, p. 13.
[223] Currie-McDaniel, p. 15.

1977, 3 Sept	DoD/USAF awards Vought Corp. prime contract for development of an ASAT Miniature Homing Vehicle (**MHV**).[224]
1977	United States declares USSR has operational ASAT capability.
1977–1982	Army conducts low-level ABM technology research.
1979, Feb	**SECDEF Brown** testifies before the House Armed Services Committee and states the U.S. land-based "ICBM survivability will have declined significantly by the early 1980s."
1979	Army BMDSCOM studies Low Altitude Defense (**LoAD**), a downscaled ABM site defense concept. The project is named **SENTRY** in 1982 and terminated 7 Jan 1983.[225]
1979–1983	MX and other land-based ICBMs survivability threatened by accurate Soviet ICBMs; MX basing debate rages; numerous proposed MX basing concepts prevent a single ABM defense concept to stabilize and be refined.
1981, 2–5 Oct	President and SECDEF Weinberger announce that the **Strategic Modernization Program** to provide effective, survivable early warning, communication, and attack assessment system; modernization of general space systems; and that United States will pursue an operational ASAT system and improve air defense surveillance and civil defense.
1982, 28 Feb	**High-Frontier Strategy** published by Heritage Foundation, arguing for a strong, national, active space defense with rapid deployment of a layered ABM system.
1983, 23 Mar	President Reagan announces the Strategic Defense Initiative (**SDI**), shifting U.S. strategy away from only offensive deterrence toward continental **active defense.**
1983, Apr	**Scowcroft Commission** publishes its modernization results, including recommending vigorous BMD R&D but not deployment of an ABM system.
1983, 1 Oct	DoD's **Miller/Hoffman Committee's** Future Security Strategy Study finalized; it recommends multi-layered BMD and broad-based evolutionary R&D in support of SDI.
1984, Feb	DoD's Defense Technologies Study Group (**Fletcher Panel**) completes its study; it recommends BMD R&D of revolutionary, high-risk technologies to resolve BM/C3, sensor, and SDI survivability problems.[226]
1985, 13 Sept	First successful satellite intercept by USAF F15/MHV.[227]

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[224] Stares, p. 184.
[225] Currie-McDaniel, pp. 20–23.
[226] Currie-McDaniel, p. 28.
[227] Burrows, p. 280.

1983–1989 **Army SDI support:**

**1983, Mar–Jun Army BMDO realigns organization to more effectively support SDI effort and shift from hard site defense to continental U.S. defense R&D. BMDO responsible for integration and management of all Army SDI research.[228]

1983, Sum Army BMDO develops **Defense in Depth layered SDI concept study.

**1983, Oct Under Secretary of the Army Ambrose grants authority to BMDO to proceed with the Airborne Optical Adjunct (AOA) airborne sensor project.

1983, FY Army BMDATC conducts **White Horse neutral particle beam R&D and endoatmospheric **HEDI** missile high-altitude feasibility study.[229]

**1984, 1 Apr HEDI concept definition contract awarded.[230]

1984, 10 June Army successfully conducts **HOE Experiment, **first** non-nuclear/kinetic destruction of a ballistic warhead in space; Army provides the **first** major SDI technology success; intercept software technology subsequently shared with USAF F15 MHV ASAT system, directly assisting USAF getting its first MHV intercept in 1985.[231]

1984, 1 July **ERIS (Exoatmospheric Reentry-vehicle Interceptor Subsystem) project office established.

1984, 1 July Sentry X-band phased-array radar research matures into Army/SDI advanced Terminal Imaging Radar (TIR**) project; project office established. Charter signed 11 Dec 1984.

1984, FY Battle Management/Command, Control, and Communications (BM/C3**) concept definition contracts awarded.

**1985, Mar KMR National Range improvement study completed.[232]

1985 1 July U.S. Army Strategic Defense Command (USASDC**) established by consolidating BMDSCOM and BMDATC, structured to support chartered projects and five SDIO Program Element efforts (**SA/BM, SATKA, KEW, DEW, and SLKT**).

**1985–1986 USASDC R&D efforts grouped as follows during this period:

>>Data Collection R&D:

-**Cobra Judy** = shipborne, S-band phased-array radar

-**OAMP** = airborne X-band dish radar

>>Evolutionary R&D:

-BM/C3, AOA, TIR, HEDI, ERIS, **SRHIT, FLAGE**

>>Revolutionary R&D:

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[228] Currie-McDaniel, pp. 26, 38.
[229] Currie-McDaniel, pp. 29, 55.
[230] Currie-McDaniel, p 55.
[231] Currie-McDaniel, p. 20; information supplied by Ballistic Missile Command HOE project manager, Mr. Ed Wilkenson, 28 September 1988.
[232] Currie-McDaniel, p. 47.

	-White Horse = NPB DEW
	-Free electron laser DEW.[233]
**1986, Mar	Director of SDIO awards USASDC HOE project the **first** Strategic Defense Technical Achievement Award of the American Defense Preparedness Association.[234]
**1986, 1 Mar	The Army's SDI program is 30% ($830 million) of the SDIO budget for FY86, with over 200 major contracts in place.[235]
**1987, Sum	Army conducts the **first** successful current technology, multi-sensor SDIO experiment, titled **SIE.**
**1988, May	Army finishes production of **first** compact, VHSIC computer/processor, titled Militarized Computer Module (**MCM**).
**1988, June	Army conducts **first** SDI, high-fidelity, real time, BM/C3 experiment, titled Experimental Version 1988 (**EV88**).
1985–1988	**Army Anti-Theater Missile (ATM) research:**
**1985, Mar	PATRIOT deployed in Europe.
**1986	SDIO designates USASDC as lead service in Theater Missile Defense (**TMD**) R&D; USASDC works closely with MICOM and co-locates TMD office with PATRIOT project office.
**1986, 20 Apr	Army successfully conducts **FLAGE**, anti-theater missile, kinetic intercept of tethered target.
**1986, 27 June	Army successfully conducts FLAGE, anti-theater missile, kinetic intercepts of free-flying target.
**1987, Jan	USASDC awards seven Phase I multinational European TMD architecture/concept definition contracts to U.S. and allied contractor teams.
**1987, 21 May	Army successfully conducts FLAGE, anti-theater missile, kinetic intercepts of flying Lance tactical missile target.
**1988, Jun	USASDC manages for SDIO two Israel-U.S. TMD contracts (**ARROW** interceptor and Israel Testbed).
1989, 9 Jan	DoD acquisition czar R. Costello and the Vice Chairman, Joint Chiefs of Staff, approve the Army as interim **executive service/manager** of a $184.2 million joint service

[233] Currie-McDaniel, p. 51.
[234] Currie-McDaniel, p. 42.
[235] Currie-McDaniel, p. 51.

ASAT program, including Army ERIS interceptors, lasers, and other beam weapons. The Deputy Secretary of Defense signs the documentation formally assigning the mission to the Army in March 89.

Appendix F

SMALL TACTICAL MISSILES AND VIETNAM WAR CHRONOLOGY

1918, Jan	U.S. Signal Corps commissions Dr. R. H. Goddard to develop military rockets, including recoilless rockets.
1918, 10 Nov	Dr. Goddard and C. H. Hickman successfully demonstrate at Aberdeen Proving Ground a bazooka-like recoilless rocket.
1918, 11 Nov	WWI Armistice signed. Futher funding of Dr. Goddard's rocket research quickly fades.
1936–1946	Army conducts solid- and liquid-propellant propulsion and guidance control R&D for long-range artillery missiles. See Long-Range Artillery/IRBM Missile History.
1946, 21 May	The War Department Equipment Board (**Stillwell Board**) studies the needs of the post-WWII Army and predictes a prominent role for **tactical missiles** in future warfare but calls for careful study of what types of missiles should be initially developed.
1944, 8 Sep	The first **V-2** hits London.
1945–1948	Army **Operation Paperclip** brings hu[illegible] of German/Austrian rocket specialists to America.
1946, 16 Apr	Army **von Braun team** begins flight testing captured V-2 rockets at **WSPG.**
1946–1966	Army develops **ground support missiles:**[236]
**1946, Aug	RSA begins technical supervision of close-in infantry support T137 **Area Saturation Weapon.**[237]
**1947	Ordnance initiates development of T133 high-explosive **artillery rocket.**[238]
**1950, Sept–Dec	Chief of Ordnance directs RSA to study development of accurate field artillery rocket (T237) and white phosphorous smoke rocket (T209).[239]
**1951, 7 Sept	Army initiates development of fin-stabilized **Area Toxic Rocket weapon,** T238.[240]
**1960	Improved **2.75-inch rocket** feasibility study initiated.
**1962, Oct	AMC assigns MICOM industrial and field support responsibility for the **Aircraft Weaponization Program** (a helicopter **aerial artillery missile** program).[241]

[236] Jolliff, pp. 40–51, Chap. VII, pp. 239–240.
[237] Joiner, p. 32.
[238] Joiner, p. 33.
[239] Joiner, p. 35.
[240] Joiner, p. 36.
[241] Jolliff, p. 118.

**1962, Nov	MICOM conducts emergency T&E/development of 1st Armored Division prototype 2.5-inch Folding Fin Aircraft Rocket (**FFAR**) to make weapon safe; it is released for deployment.
**1965	SECDEF assigns Army tri-service R&D responsibility for 2.75-inch rocket.
**1966	Army/USAF agreement allows ground service to operate helicopter gunships; DoD replaces the Army fixed-wing aircraft in the fighter-escort mission with helicopters.[242]
1949–1975	Army develops **small anti-tank missiles:**[243]
**1949, May	RSA begins technical supervision of an improved 3.5-inch anti-tank rocket motor.[244]
**1952, May	Office, Chief of Ordnance, directs RSA to begin study of lightweight, shoulder-fired anti-tank rocket, T266.[245]
**1953	Picatinney Arsenal and RSA begin development of armor-piercing rockets T277 and T280 and fragmentation rocket T282.[246]
**1958, Feb	**LAW** shoulder-fired, solid-propellant, anti-tank weapon feasibility study initiated.
**1958. Mar	**Shillelagh** feasibility study initiated.
**1961, Mid	AMC begins supervising production and deployment to Vietnam of U.S.-produced, French-designed, wire-guided missiles for use by infantry.
**1962, Jan	**TOW** feasibility study initiated.
**1962, Oct	AMC assigns responsibility for T&E and procurement of foreign weapon systems, including the French **ENTAC**, **SS-10**, and **SS-11**, and responsibility for free rocket R&D, including LAW, M74 **Flame**, and M55 **Chemical rocket.**
**1964, Aug	**Dragon** feasibility study initiated.
**1967	**Viper** feasibility study initiated, never deployed.
**1967, Jun	Shillelagh initially deployed.
**1968, Feb	AMC authorizes MICOM to initiate reverse engineering of Soviet **RPG-7** and recommend emergency production of a similar weapon; MICOM recommends 6- and 9-month LAW missile production options.
**1968, Apr	**USARV** establishes **ENSURE** (Expedite Non-standard Urgent Requirement for Equipment) for RPG-7-like anti-tank/point target missile weapon.
**1969	LAW initially deployed in Vietnam, emergency production and deployment.

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[242]Jolliff, p. 117.
[243]Jolliff, pp. 40–51, Chap. VII, pp. 239–240.
[244]Joiner, p. 32.
[245]Joiner, p. 37.
[246]Joiner, p. 38.

**1972, Apr	**Airborne TOW** initially deployed in Vietnam, emergency deployment in response to North Vietnamese invasion across Demilitarized Zone 30 Mar 1972.
**1972, 2 May	The **first** American-made airborne **TOW** anti-tank missiles are fired in combat near Kontum, Vietnam, destroying four captured U.S. M41 tanks.
**1972, May	Ground TOW initially deployed in Vietnam, emergency deployment.
**1975, Mar	Dragon initially deployed.
1951–1972	Army develops **small anti-aircraft missiles.**[247]
**1951, Jan	Joint Chiefs of Staff authorize Army to investigate low-altitude surface-to-air anti-aircraft missiles.[248]
**1951, Jan	RSA begins demonstrating feasibility of T212 spin stabilized, high-explosive, anti-aircraft rocket.[249]
**1951, Mar	**HAWK** feasibility study initiated.
**1953, Apr–July	Ordnance Department establishes HAWK low-level, anti-aircraft missile program, assigns RSA technical responsibility.[250]
**1955, 16 Aug	**First** successful HAWK missile firing, WSPG.[251]
**1958, Apr	**Redeye** feasibility study initiated.
**1958, May	Army HAWK missile makes **first** successful intercept of a low-altitude aircraft (F80 jet at treetop level).
**1958, Jun	**Mauler** feasibility study initiated, never deployed.
**1960, Jan	HAWK makes **first** intercept of an Honest John tactical missile.
**1960, Aug	HAWK initially deployed in Vietnam.
**1963, Sep	**Chaparral** feasibility study initiated.
**1964, Nov	**Stinger**(Redeye II) feasibility study initiated.
**1965, Mid	Dept. of Army assigns MICOM responsibility for developing an operation plan for efficient missile support for high-cost low-density missile systems to correct HAWK system downtime difficulties in Vietnam.
**1967, Oct	Redeye initially deployed.
**1967	Israelis conduct first combat firing of U.S. surface-to-surface missiles by downing several Egyptian jets with HAWK missiles during the Six Day War.
**1969, Nov	Initial deployment of Chaparral employs ground-launched Navy Sidewinder missiles.[252]

[247] Jolliff, pp. 40–51, Chap. VII, pp. 239–240.
[248] Joiner, pp. 43–44.
[249] Joiner, p. 36.
[250] Joiner, p. 44.
[251] Perry, p. 13.
[252] "Missiles in Service," p. 16.

**1972	**U.S. Roland** feasibility study initiated, never deployed.
1960, Mar–Sept	**AOMC** realigns personnel, missions, and roles after transfer of ABMA Development Operations Division. ABMA assumes responsibility for long-range artillery missiles and anti-tank weapons. Assigned Corporal, Sergeant, Honest John, Littlejohn, LAW, missile A and missile B (Lance). **Army Rocket and Guided Missile Agency** assumes responsibility for air and space defense missiles and maneuverable missile systems, assigns Nike Ajax, Nike Zeus, Nike-Hecules, HAWK, Redeye, Mauler, and Shillelagh.
1962, 8 May	As part of 1962 Army reorganization, Army Materiel Command (**AMC**) established.
1962, 1 Aug	U.S. Missile Command (**MICOM**) established, as a subordinate command within AMC, by consolidating AOMC.
1961–1973	U.S. Army fights war in Vietnam:
**1961, Dec	President Eisenhower establishes Military Assistance Advisory Group (**MAAG**) to supervise and coordinate military support to **South Vietnam.**[253]
**1965, 5 May	First U.S. Army combat troops arrive in **Republic** of Vietnam.[254]
**1965, 20 July	U.S. Army Vietnam (**USARV**) established with approximately 30,000 troops.[255]
**1969, Jan	U.S. Army personnel strength peaks at 365,000.
**1973, 28 Mar	All U.S. personnel leave RVN, USARV deactivated.[256]

[253] Jolliff, p. 115.
[254] Jolliff, p. 115.
[255] Jolliff, p. 116.
[256] Jolliff, p. 116.

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